# Test Report

FINAS
Finnish Accreditation Service
T004 (EN ISO/IEC 17025)

## INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 15C AND INDUSTRY CANADA REQUIREMENTS

| | |
|---|---|
| Equipment Under Test: | Bluetooth v.2.1 + EDR module |
| Model: | WT41u-A<br>WT41u-E |
| Brand: | Silicon Labs |
| Customer / Manufacturer: | Silicon Laboratories Finland Oy<br>Bertel Jungin aukio 3<br>FI-02600 Espoo<br>FINLAND |
| FCC Rule Part: | 15.247:2015 |
| IC Rule Part: | RSS-247, Issue 1, 2015<br>RSS-GEN Issue 4, 2014 |
| KDB: | Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems<br>DA 00-705 (March 30, 2000) |

Date: 20 October 2016
Issued by:
Emil Haverinen
Testing Engineer

Date: 20 October 2016
Checked by:
Rauno Repo
Testing Engineer

**Table of Contents**

## Equipment Under Test (EUT)

| | |
|---|---|
| Trade mark: | Silicon Labs |
| Model: | WT41u-A, WT41u-E |
| Type: | Bluetooth v.2.1 + EDR module |
| Serial no: | - |
| FCC ID: | QOQWT41U |
| IC: | 5123A-WT41U |

## Description of the EUT

The equipment under test is a Bluetooth v.2.1 + EDR module.

## Classification of the device

| | |
|---|---|
| Fixed device | ☐ |
| Mobile Device (Human body distance > 20cm) | ☒ |
| Portable Device (Human body distance < 20cm) | ☐ |

## Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

## Ratings and declarations

| | |
|---|---|
| Operating Frequency Range (OFR): | 2402 - 2480 GHz |
| Channels: | 79 |
| Channel separation: | 1 MHz |
| 99% Channel bandwidth: | 1.217149464 MHz (3 Mbps / ch low) |
| Maximum peak conducted output power: | 18.04 dBm (normal conditions) |
| Transmission technique: | FHSS |
| Modulation: | GFSK, π/4 DQPSK, 8DPSK |
| Integral antenna gain (WT41u-A): | 0 dBi |
| External antenna gain (WT41u-E): | 2.14 dBi |

## Power Supply

| | |
|---|---|
| Operating voltage range: | 3.0 – 3.6 VDC, tested with 3.3 VDC |

## Mechanical Size of the EUT

| | | |
|---|---|---|
| Height: 3.35 mm | Width: 14.00 mm | Depth: 35.30 mm |

## Samples

One sample from both models was used in tests.

## Disclaimer

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*Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 90 days only. This document cannot be reproduced except in full, without prior approval of the Company.*

# SUMMARY OF TESTING

| Test Specification | Description of Test | Result |
|---|---|---|
| §15.207(a) / RSS-GEN 8.8 | Conducted Emissions on Power Supply Lines | **PASS** |
| §15.247(b)(1) / RSS-247 5.4(2) | Maximum Peak Conducted Output Power | **PASS** |
| 15.247(a)(1) / RSS-247 5.1(2) | Hopping Channel Carrier Frequency Separation | **PASS** |
| §15.247(a)(1)(iii) / RSS-247 5.1(4) | Number of Hopping Frequencies | **PASS** |
| §15.247(a)(1)(iii) / RSS-247 5.1(4) | Average Time of Occupancy of Hopping Frequency | **PASS** |
| §15.247(a)(1) / RSS-247 5.1(2) | 20 dB Bandwidth | **PASS** |
| RSS-GEN 6.6 | 99 % Occupied Bandwidth | **PASS** |
| §15.247(d) / RSS-247 5.5 | 100 kHz Bandwidth of Frequency Band Edges and Conducted Spurious Emissions | **PASS** |
| §15.209(a), §15.247(d) / RSS-247 5.5 | Radiated Emissions Within The Restricted Bands | **PASS** |

**Explanations:**
PASS The EUT passed that particular test.
FAIL The EUT failed that particular test.
N/A Not Applicable
N/T Not Tested

## Test Facility

| | | |
|---|---|---|
| ☐ | Testing Location / address:<br>FCC registration number: **90598** | SGS Fimko Ltd<br>Särkiniementie 3<br>FI-00210, HELSINKI<br>FINLAND |
| ☒ | Testing Location / address:<br>FCC registration number: **178986**<br>Industry Canada registration number: **8708A-2** | SGS Fimko Ltd<br>Karakaarenkuja 4<br>FI-02610, ESPOO<br>FINLAND |

## EUT Test Conditions during Testing

The EUT was in continuous transmit mode during all the tests. When necessary the hopping was stopped and the EUT was configured into the wanted channel. Normal modulation was applied in all the tests.

The radiated measurements were performed to both models separately. The A -variant of the EUT was using its normal chip antenna and the E -variant was fitted with antenna and short RF cable adapter provided by the manufacturer. Radiated measurements were performed only with 1 Mbps data rate (highest power).

The conducted measurements were performed only to E -variant because the only difference between the modules is that the E -variant has and RF connector instead of the chip antenna used by the A -variant. Conducted measurements were performed with 1(power setting 46) and 3 Mbps data rates.

During conducted emissions on AC power supply lines test, the EUT was powered from Flextronics LPS 0012ADU00 AC/DC power supply. Supply voltage and frequency of 115 V / 60 Hz was used. The supply provides 5.2 VDC / 2.4 A output which was used to supply evaluation board of the EUT. Evaluation board regulates voltage to 3.3 V which is supplied to the EUT. In other tests the power was supplied from the laboratory power supply.

Both models were connected to their supportive evaluation boards while tests were performed.

Average values for transmitter radiated emissions were calculated from measured peak pulse amplitude and by determining the duty cycle correction factor of the pulse modulation as described in ANSI 63.10 clause 7.5.

**The duty cycle correction expressed in dB was determined as follows:**

Duty cycle correction = 20log (Δ), Δ(duty cycle) = 2.915 ms / 100 ms = 0.02915

Pulse repetition time is >100 ms

Calculated duty cycle correction for the EUT = -30.7 dB

**Following channels were used during the tests when the hopping was stopped:**

Channel Low = 2402 MHz
Channel Mid = 2441 MHz
Channel High = 2480 MHz

**Power settings during the tests:**

WT41u-A: 255, 46 / 255, 82 (Basic data rate / Enhanced data rate)
WT41u-E: 255, 44 / 255, 82 (Basic data rate / Enhanced data rate 2DH5 + 3DH5)

**Packet settings during the tests:**

Basic data rate: 15, 339 (type, size)
Enhanced data rate 2DH5: 30, 679 (type, size)
Enhanced data rate 3DH5: 31, 1021 (type, size)

## Conducted Emissions on Power Supply Lines

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | EHA | |
| **Date:** | 14 October 2016 | |
| **Temperature:** | 22 °C | |
| **Humidity:** | 31 % RH | |
| **Measurement uncertainty:** | ± 2.9 dB | Level of confidence 95 % (k = 2) |

**FCC Rule: §15.207 (a)**
**RSS-GEN 8.8**

Conducted disturbance voltage was measured with an artificial main network from 150 kHz to 30 MHz with 4.5 kHz steps and a resolution bandwidth of 9 kHz. Measurements were carried out with peak and average detectors.

**Table 1:** Conducted emission limits

| Frequency of emission (MHz) | Conducted limit (dBµV) | |
|---|---|---|
| | Quasi-peak | Average |
| 0.15-0.5 | 66 to 56* | 56 to 46* |
| 0.5-5 | 56 | 46 |
| 5-30 | 60 | 50 |

*Decreases with the logarithm of the frequency.

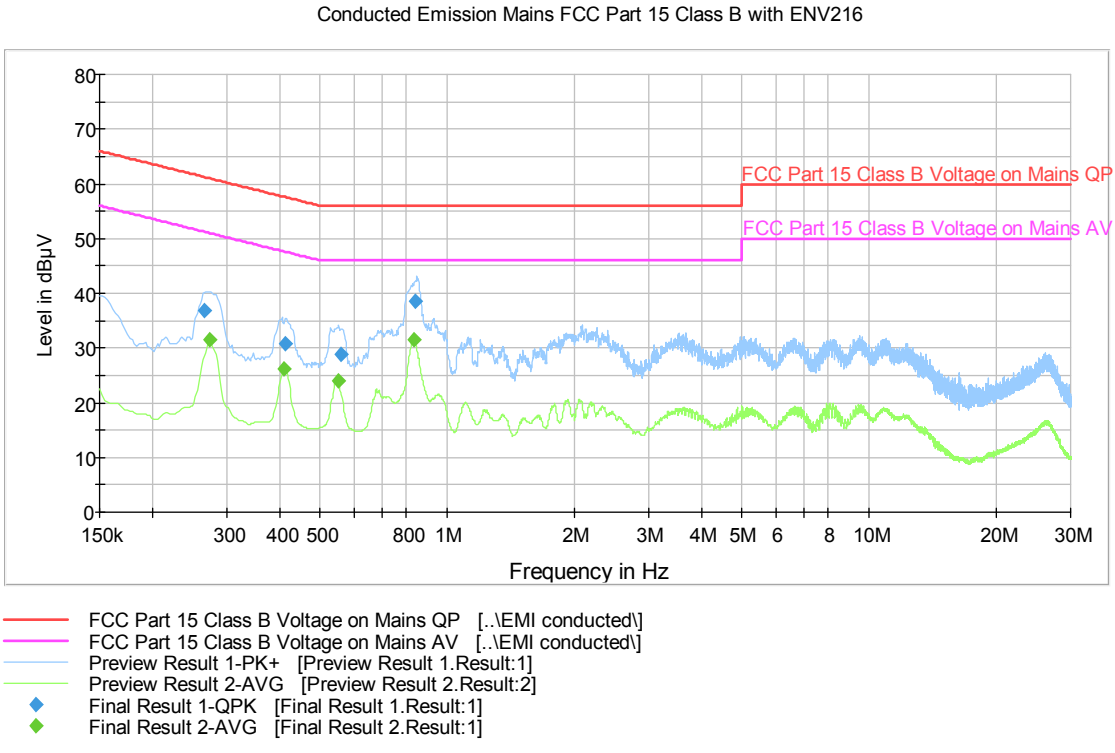


**Figure 1:** Measurement results from AC-mains with peak and average detectors

**Table 2:** Final quasi peak measurements from the worst frequencies

| Frequency (MHz) | QuasiPeak (dBµV) | Meas. Time (ms) | Bandwidth (kHz) | Filter | Line | Corr. (dB) | Margin (dB) | Limit (dBµV) |
|---|---|---|---|---|---|---|---|---|
| 0.266250 | 36.9 | 1000.0 | 9.000 | On | L1 | 9.8 | 24.4 | 61.2 |
| 0.412250 | 30.8 | 1000.0 | 9.000 | On | N | 10.2 | 26.8 | 57.6 |
| 0.562000 | 28.8 | 1000.0 | 9.000 | On | N | 10.2 | 27.2 | 56.0 |
| 0.840000 | 38.5 | 1000.0 | 9.000 | On | N | 10.3 | 17.5 | 56.0 |

**Table 3:** Final average measurements from the worst frequencies

| Frequency (MHz) | Average (dBµV) | Meas. Time (ms) | Bandwidth (kHz) | Filter | Line | Corr. (dB) | Margin (dB) | Limit (dBµV) |
|---|---|---|---|---|---|---|---|---|
| 0.273250 | 31.4 | 1000.0 | 9.000 | On | L1 | 9.8 | 19.6 | 51.0 |
| 0.411500 | 26.2 | 1000.0 | 9.000 | On | N | 10.2 | 21.4 | 47.6 |
| 0.552500 | 24.0 | 1000.0 | 9.000 | On | N | 10.3 | 22.0 | 46.0 |
| 0.835750 | 31.5 | 1000.0 | 9.000 | On | N | 10.3 | 14.5 | 46.0 |

## Maximum Peak Conducted Output Power

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | EHA | |
| **Date:** | 13 October 2016 | |
| **Temperature:** | 21 °C | |
| **Humidity:** | 33 % RH | |
| **Measurement uncertainty:** | ± 2.87dB | Level of confidence 95 % (k = 2) |

**FCC Rule: §15.247(b)(1)**
**RSS-247: 5.4(2)**

For frequency hopping systems operating in the 2400-2483.5 MHz, employing at least 75 channels limit is 1.0 Watt. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

**Test results:**

**Table 4:** Maximum conducted output power (1 Mbps, GFSK modulation)

| Channel | Conducted Power [dBm] | Limit [dBm] | Margin [dBm] | Result |
|---|---|---|---|---|
| Low | **17.74** | 30 | 12.26 | **PASS** |
| Mid | 17.25 | 30 | 12.75 | **PASS** |
| High | 16.31 | 30 | 13.69 | **PASS** |

**Table 5:** Maximum conducted output power (2 Mbps, π/4 DQPSK modulation)

| Channel | Conducted Power [dBm] | Limit [dBm] | Margin [dBm] | Result |
|---|---|---|---|---|
| Low | **11.16** | 30 | 18.84 | **PASS** |
| Mid | 10.19 | 30 | 19.81 | **PASS** |
| High | 8.21 | 30 | 21.79 | **PASS** |

**Table 6:** Maximum conducted output power (3 Mbps, 8DPSK modulation)

| Channel | Conducted Power [dBm] | Limit [dBm] | Margin [dBm] | Result |
|---|---|---|---|---|
| Low | **11.43** | 30 | 18.57 | **PASS** |
| Mid | 10.24 | 30 | 19.76 | **PASS** |
| High | 8.60 | 30 | 21.40 | **PASS** |

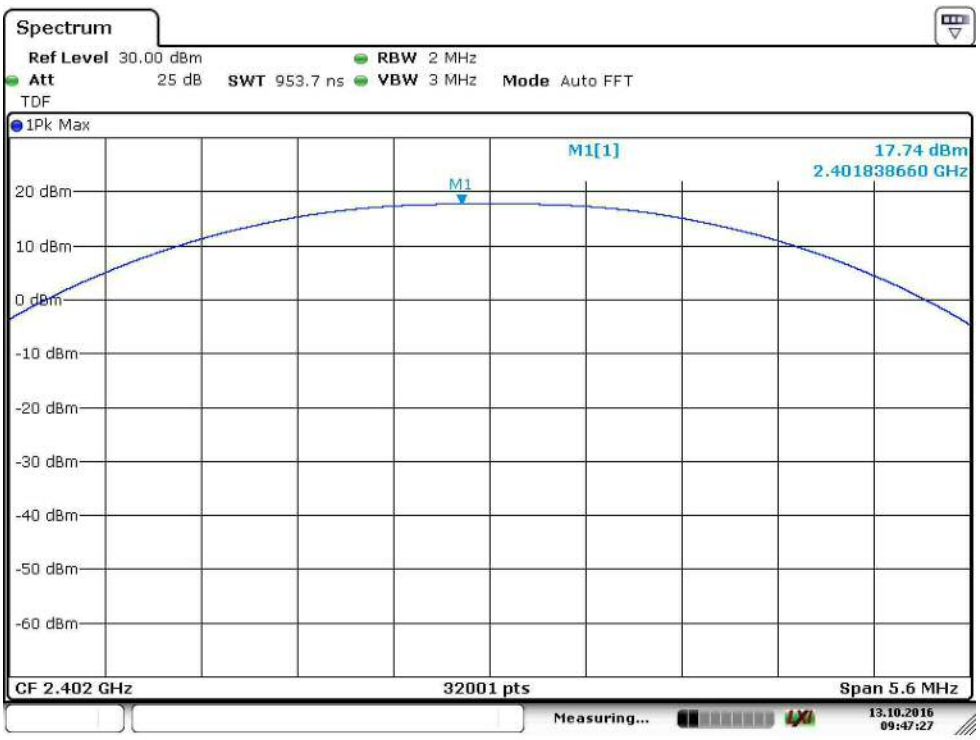


**Figure 2.** Maximum peak output power channel low (1 Mbps)

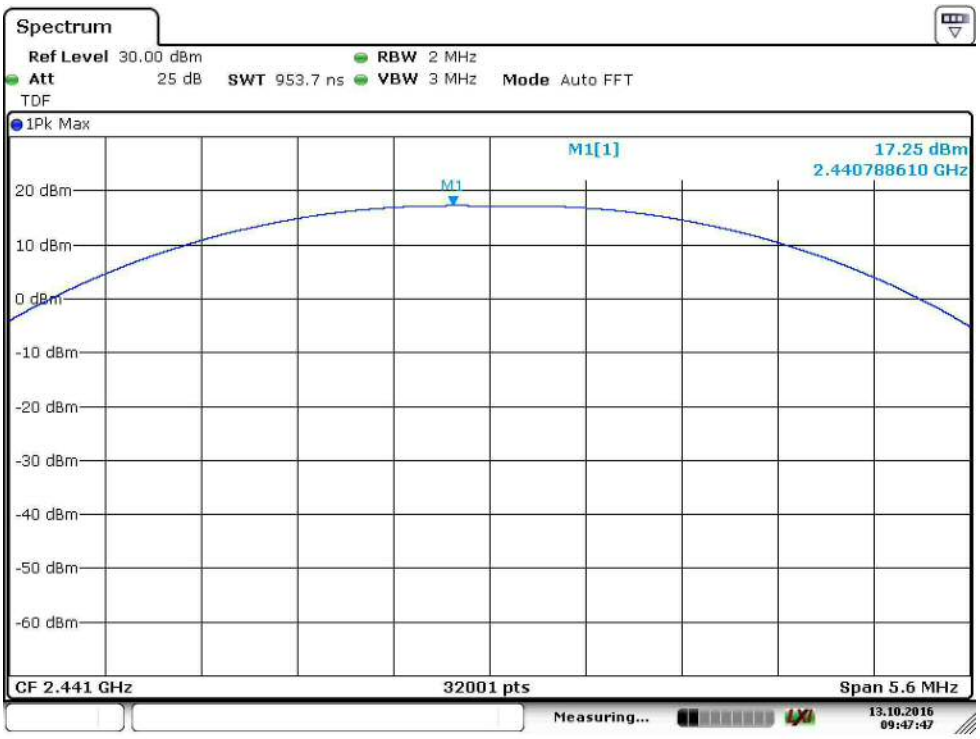


**Figure 3.** Maximum peak output power channel mid (1 Mbps)

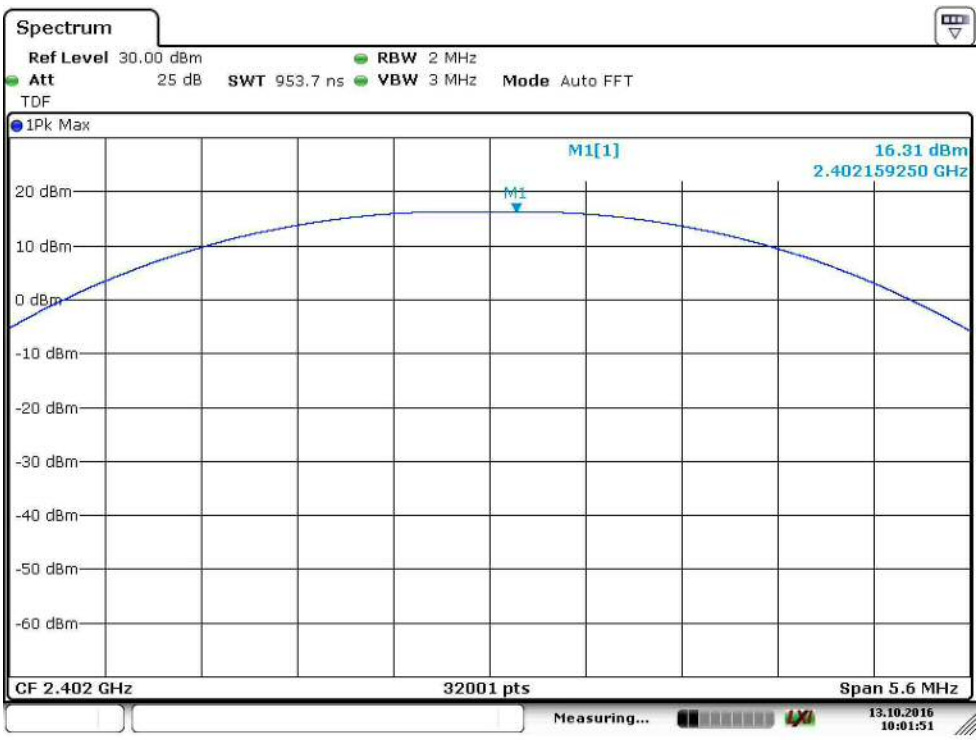


**Figure 4.** Maximum peak output power channel high (1 Mbps)

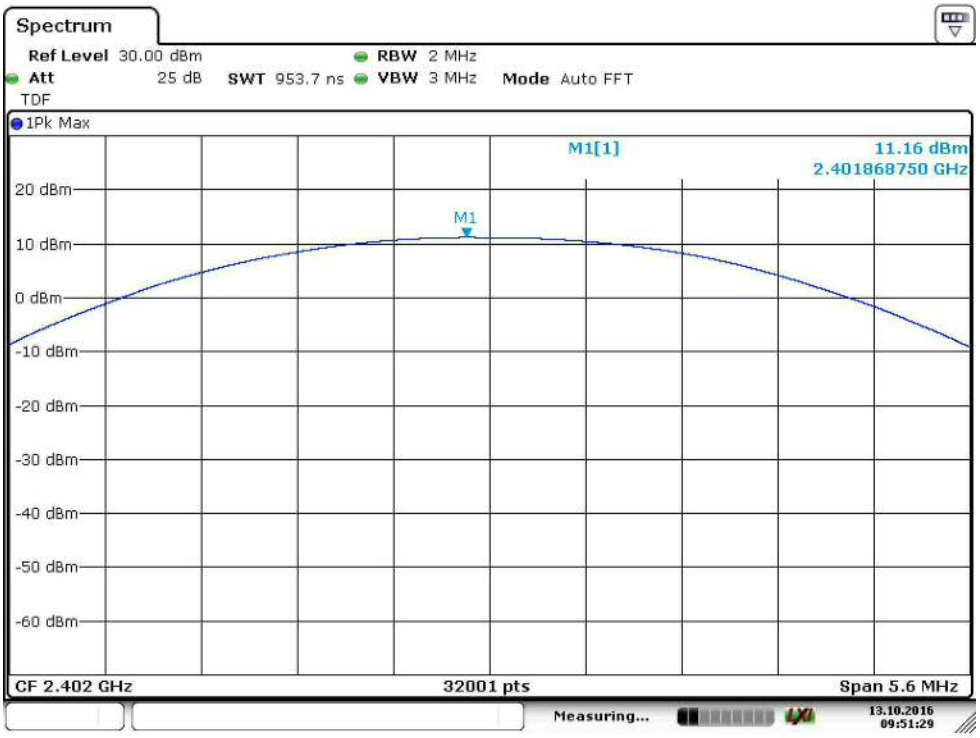


**Figure 5.** Maximum peak output power channel low (2 Mbps)

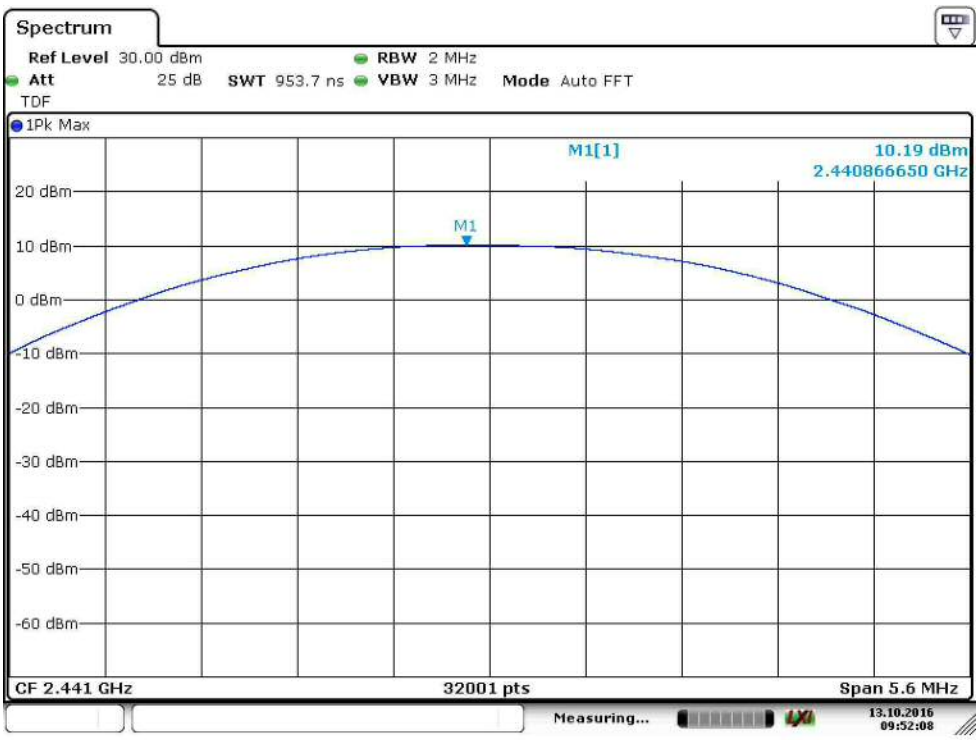


**Figure 6.** Maximum peak output power channel mid (2 Mbps)

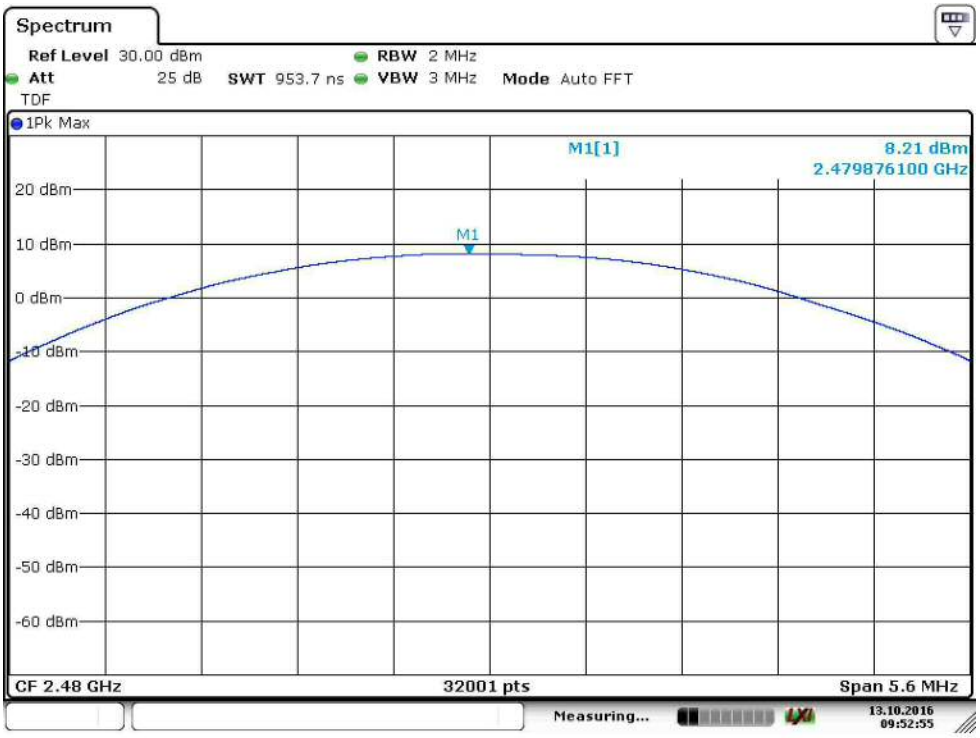


**Figure 7.** Maximum peak output power channel high (2 Mbps)

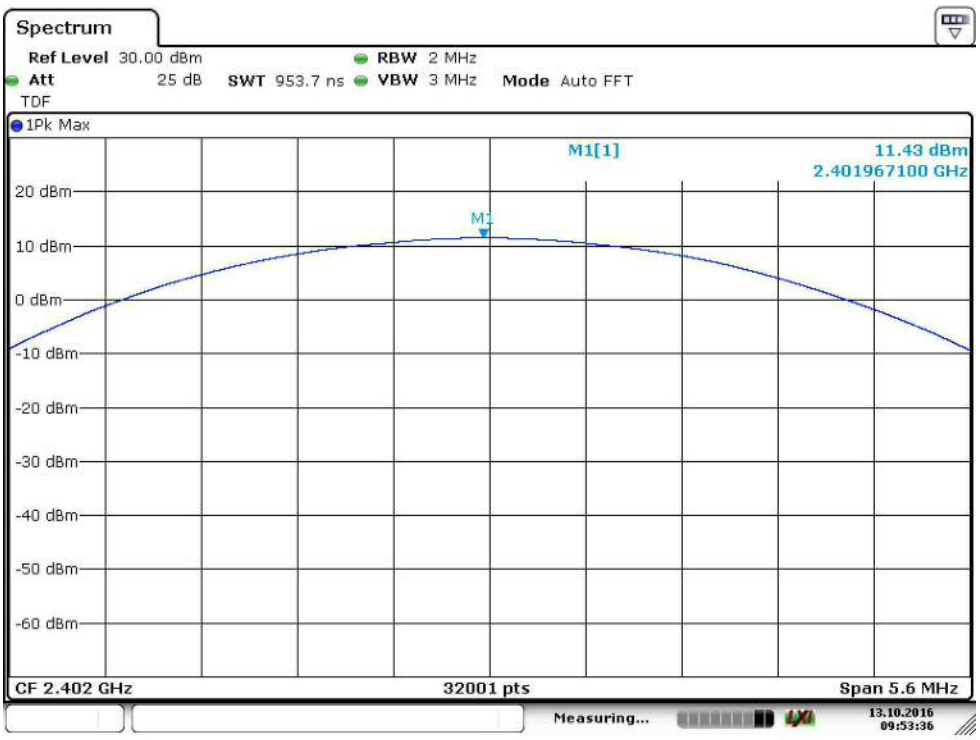


**Figure 8.** Maximum peak output power channel low (3 Mbps)

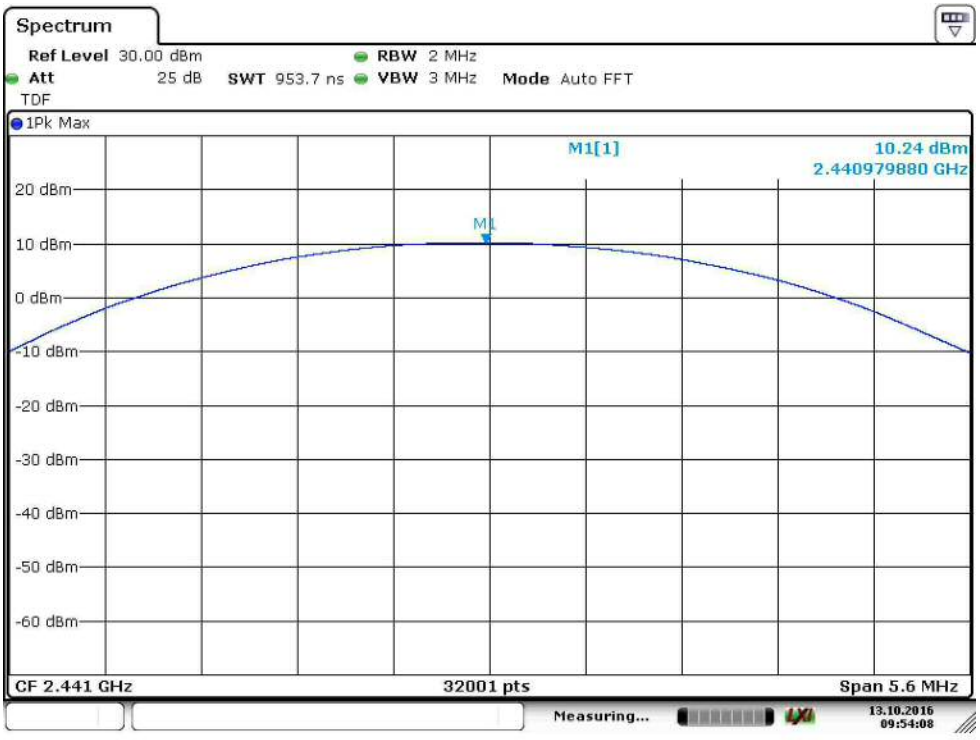


**Figure 9.** Maximum peak output power channel mid (3 Mbps)

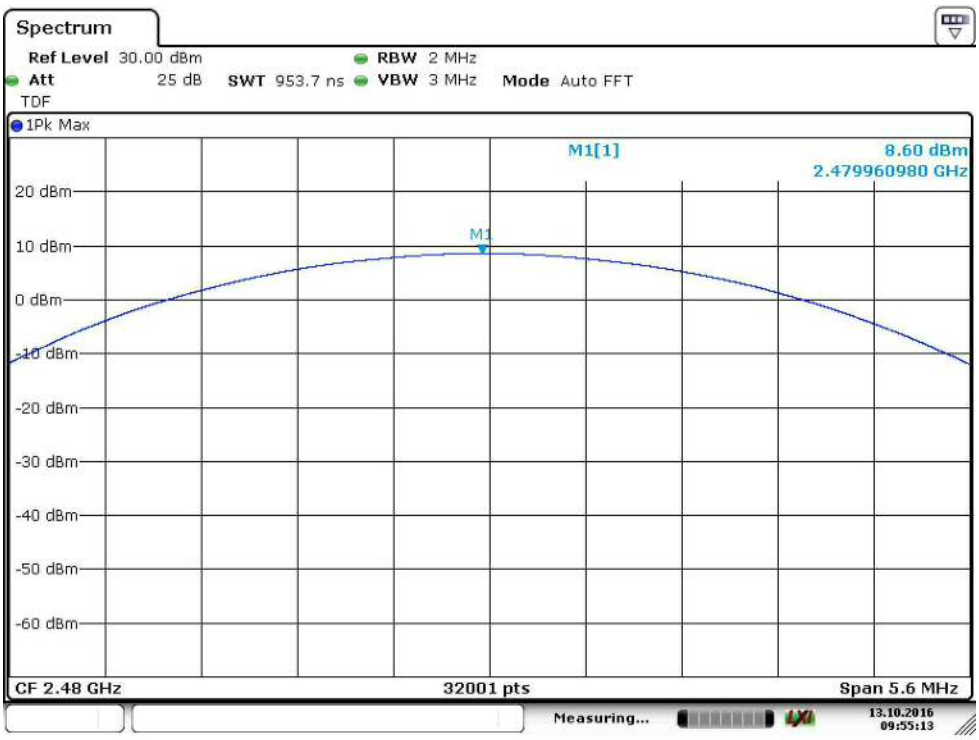


**Figure 10.** Maximum peak output power channel high (3 Mbps)

## Hopping Channel Carrier Frequencies Separation

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | EHA | |
| **Date:** | 13 October 2016 | |
| **Temperature:** | 21 °C | |
| **Humidity:** | 33 % RH | |

**FCC Rule: §15.247(a)(1)**
**RSS-247 5.1(2)**

Frequency hopping systems with an output power less than 125mW shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or 2/3 of the 20 dB bandwidth of the hopping channel, whichever is greater.

**Test result:**

**Table 7:** Hopping channel carrier frequencies separation test result

| Data rate | Measured separation | Limit | Result |
|---|---|---|---|
| 1 Mbps (GFSK) | 996.380 kHz | 546.399 kHz | PASS |
| 3 Mbps (8DPSK) | 999.030 kHz | 836.099 kHz | PASS |

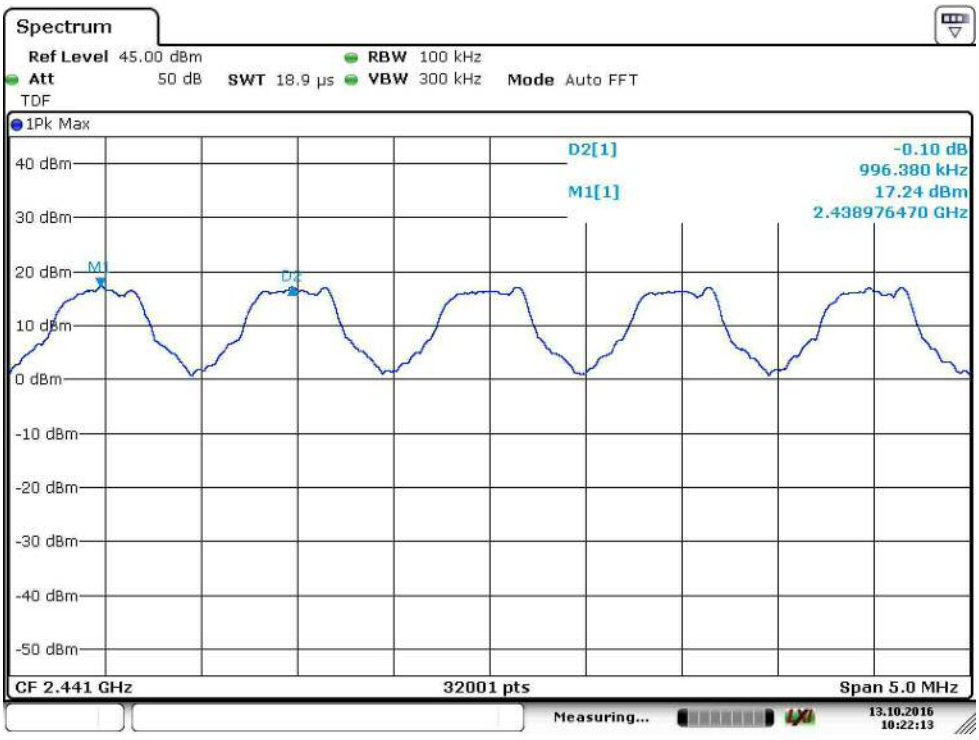


**Figure 11:** Channel frequency separation 1 Mbps

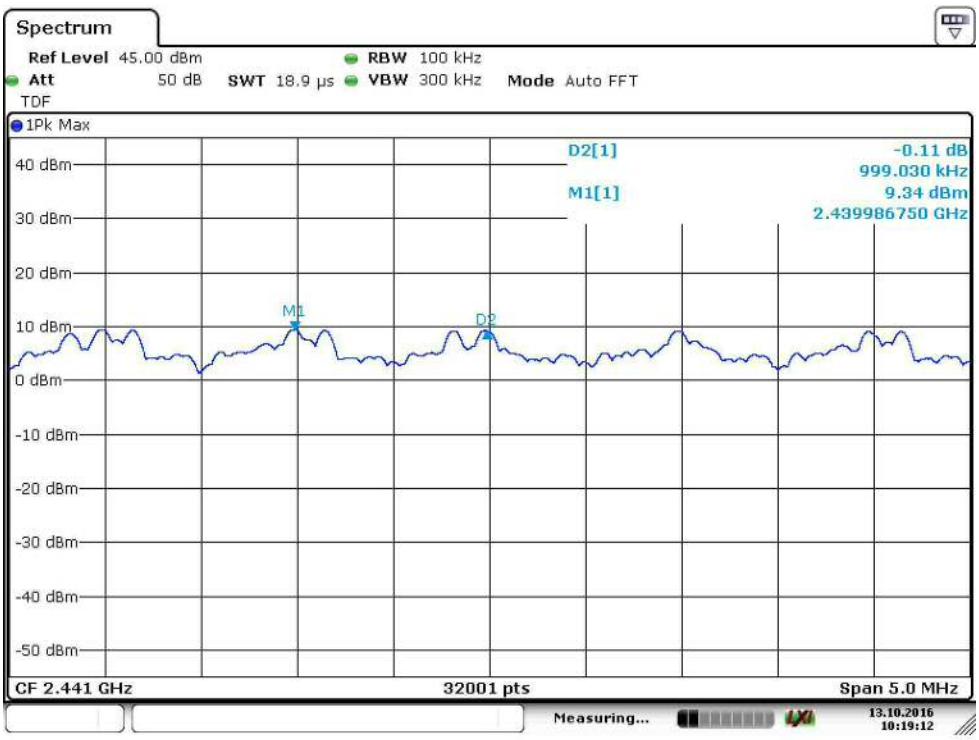


**Figure 12:** Channel frequency separation 3 Mbps

## Number of Hopping Frequencies

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | EHA | |
| **Date:** | 13 October 2016 | |
| **Temperature:** | 21 °C | |
| **Humidity:** | 33 % RH | |

**FCC Rule: §15.247(a)(1)(iii)**
**RSS-247 5.1(4)**

For frequency hopping systems operating in the 2400 - 2483.5 MHz band shall use at least 15 channels.

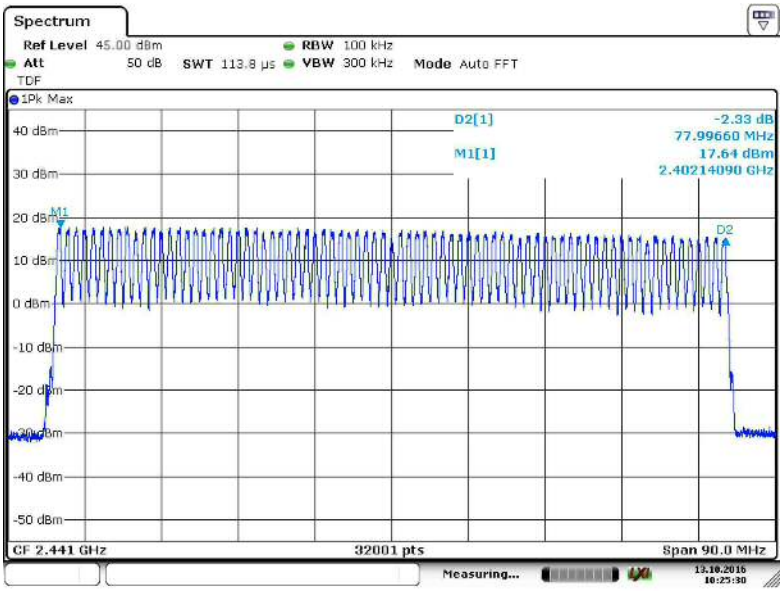


**Figure 13.** 79 hopping channels 1 Mbps

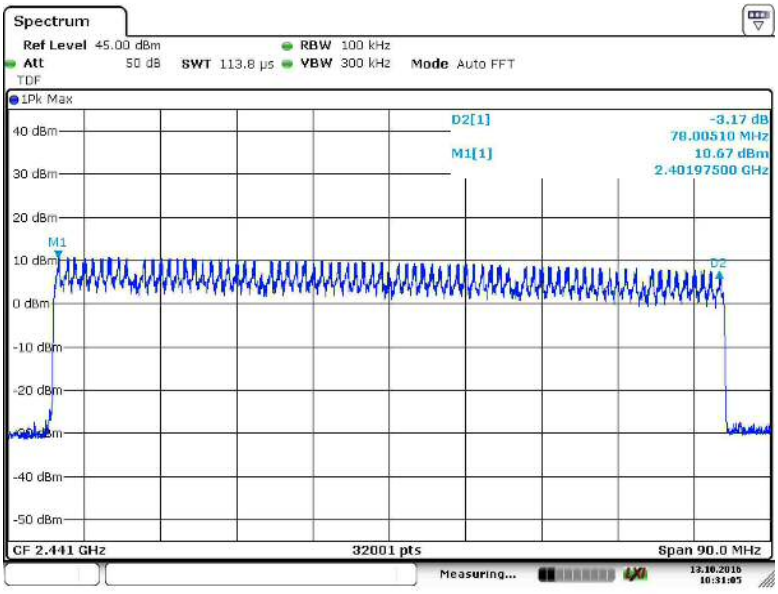


**Figure 14:** 79 hopping channels 3 Mbps

## Average Time of Occupancy of Hopping Frequency

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | EHA | |
| **Date:** | 13 October 2016 | |
| **Temperature:** | 21 °C | |
| **Humidity:** | 33 % RH | |

**FCC Rule: §15.247(a)(1)(iii)**
**RSS-247 5.1(4)**

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

Test was performed in each data rate mode to insure that the all modes are identical.

**Time of occupancy calculation:**
Number of channels = 79
Measurement period = 0.4 s x 79 = 31.6 s
One channel occupancy time = 297.8 ms
Number of transmission cycles in measurement period = 31.6 / 0.2978 = 106.1
Time of occupancy = (single duration) x (repetition) = 2.915 ms x 106.1 = 309.28 ms

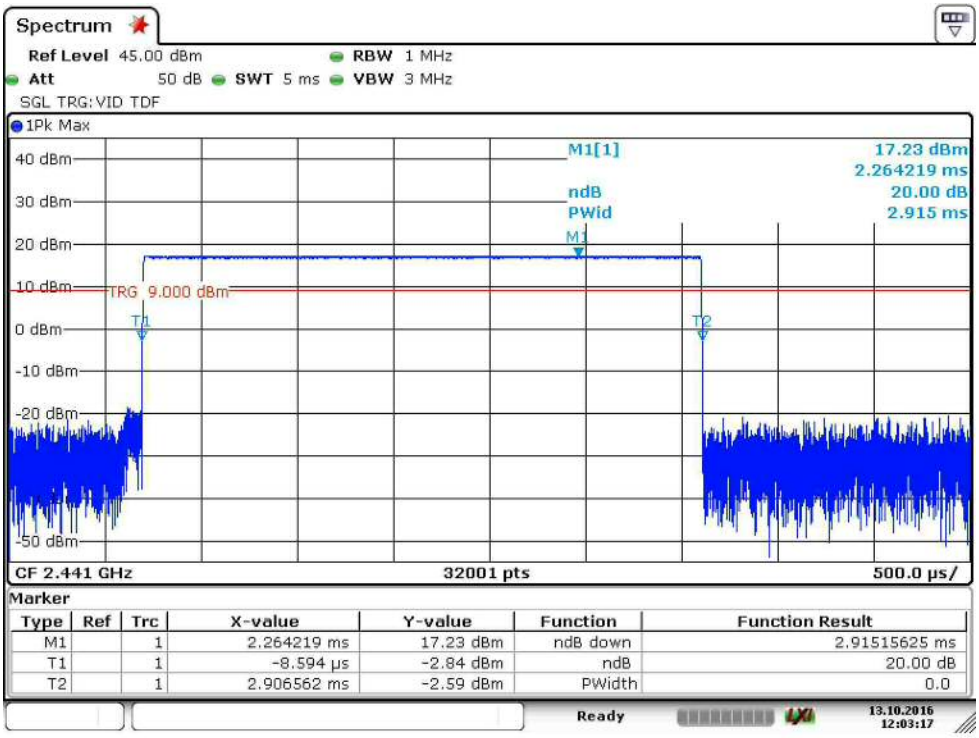


**Figure 15:** Duration of one transmission

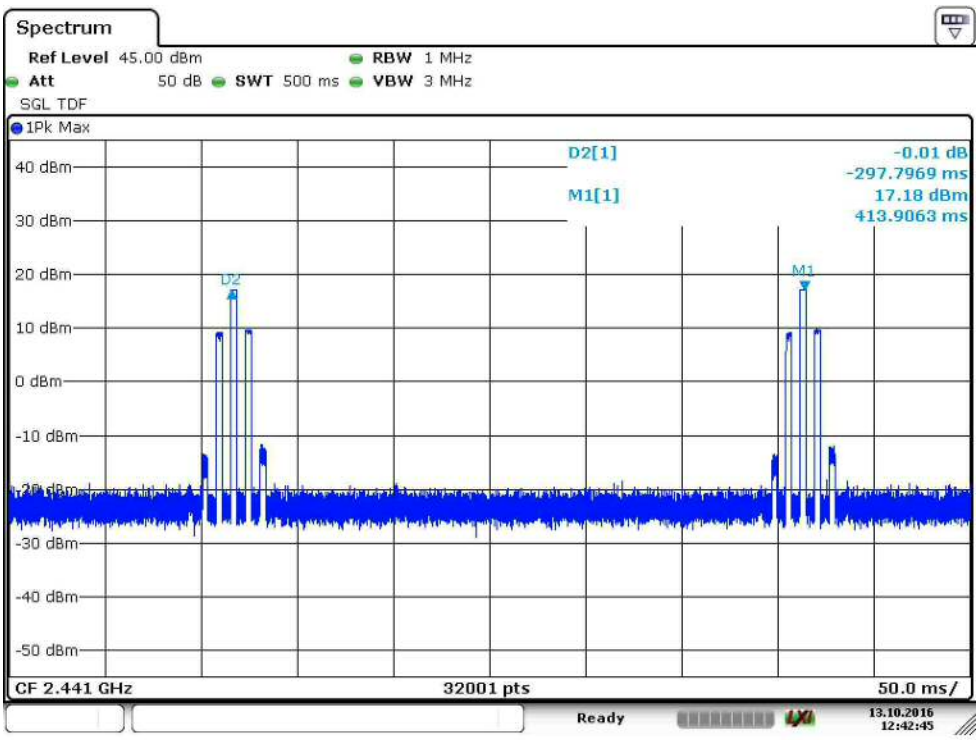


**Figure 16:** Channel transmission repetition rate

## 20 dB Bandwidth

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | EHA | |
| **Date:** | 13 October 2016 | |
| **Temperature:** | 21 °C | |
| **Humidity:** | 33 % RH | |

**FCC Rule: §15.247(a)(1)**
**RSS-247 5.1(2)**

**Test result:**

**Table 8.** 20 dB bandwidth test results

| Channel | 20 dB BW [kHz] 1 Mbps (GFSK) | 20 dB BW [kHz] 3 Mbps (8DPSK) |
|---|---|---|
| Low | 817.849 | 1211.712 |
| Mid | 818.162 | 1254.148 |
| High | 819.599 | 1213.275 |

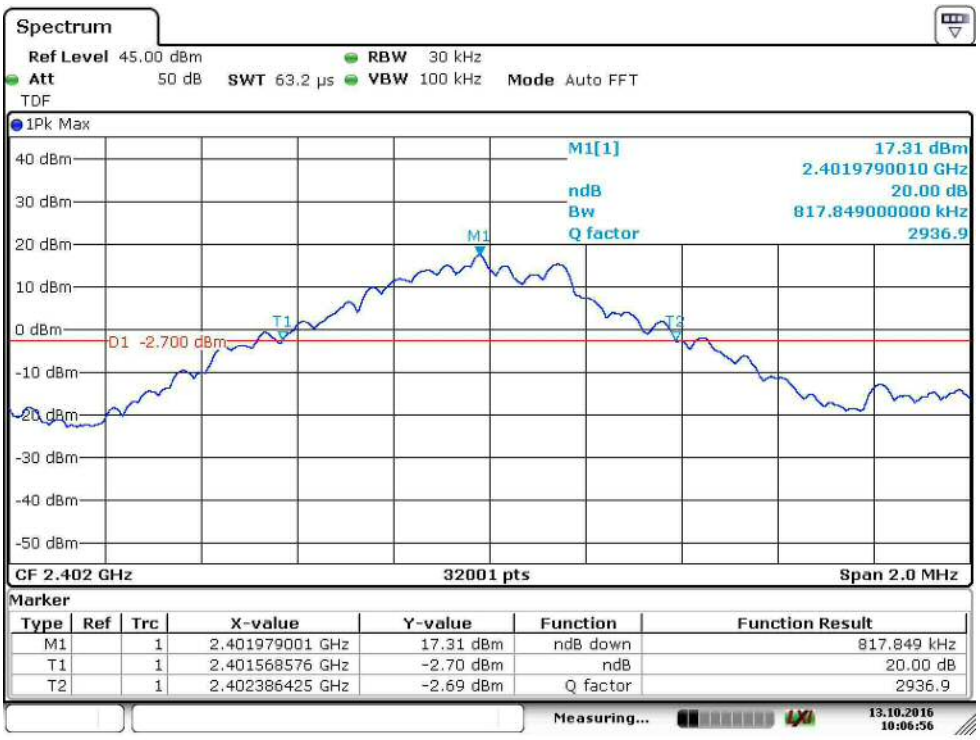


**Figure 17:** 20 dB bandwidth channel low (1 Mbps)

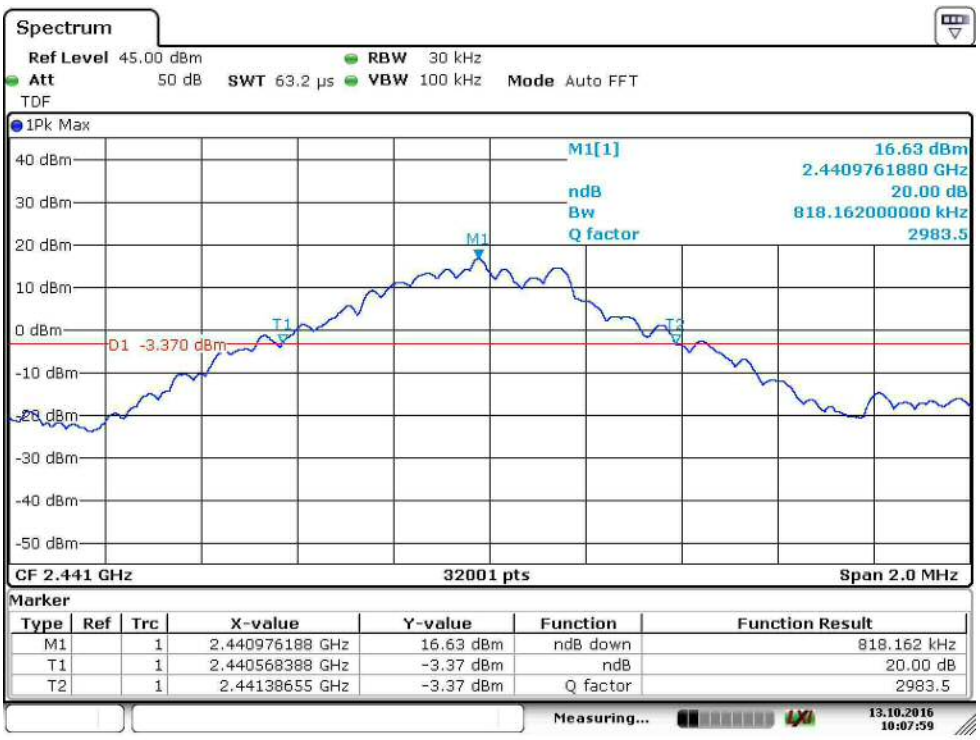


**Figure 18:** 20 dB bandwidth channel mid (1 Mbps)

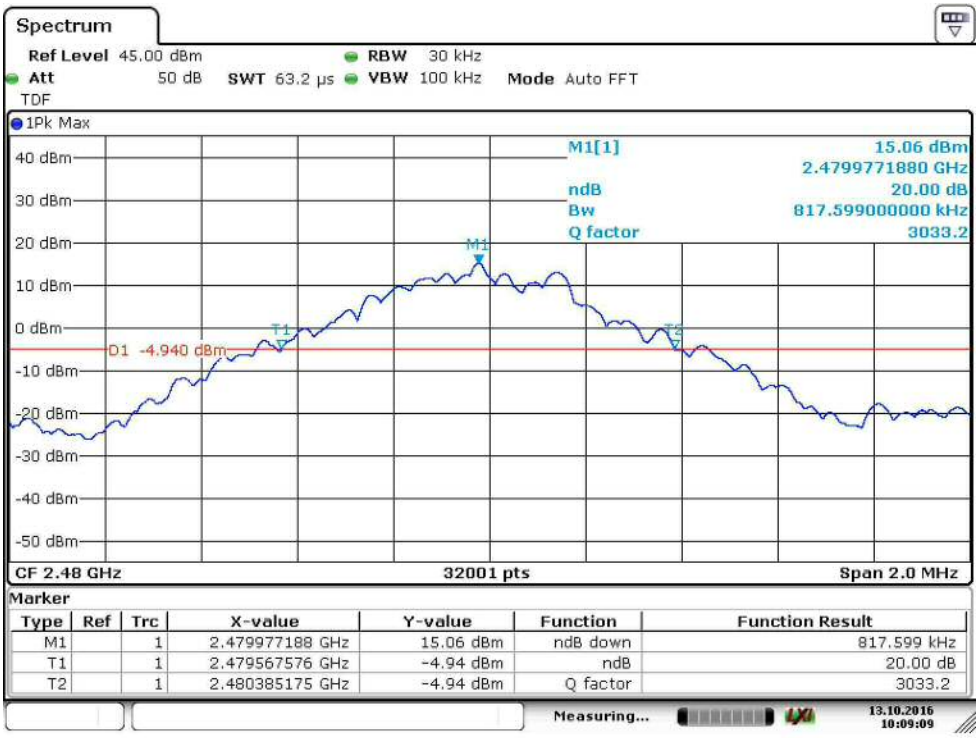


**Figure 19:** 20 dB bandwidth channel high (1Mbps)

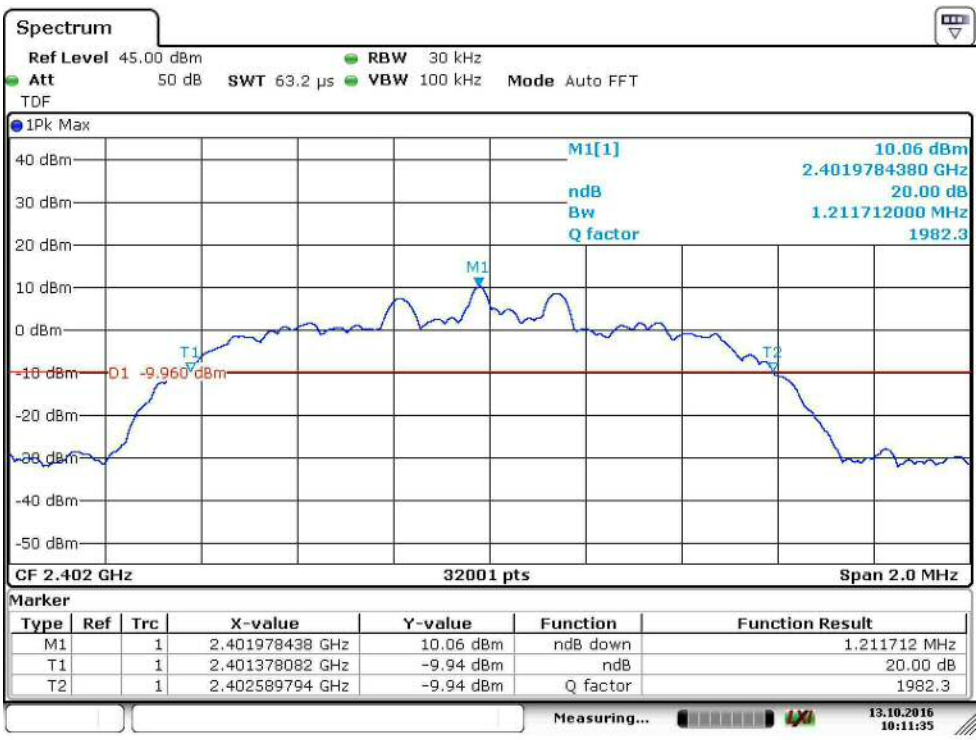


**Figure 20:** 20 dB bandwidth channel low (3 Mbps)

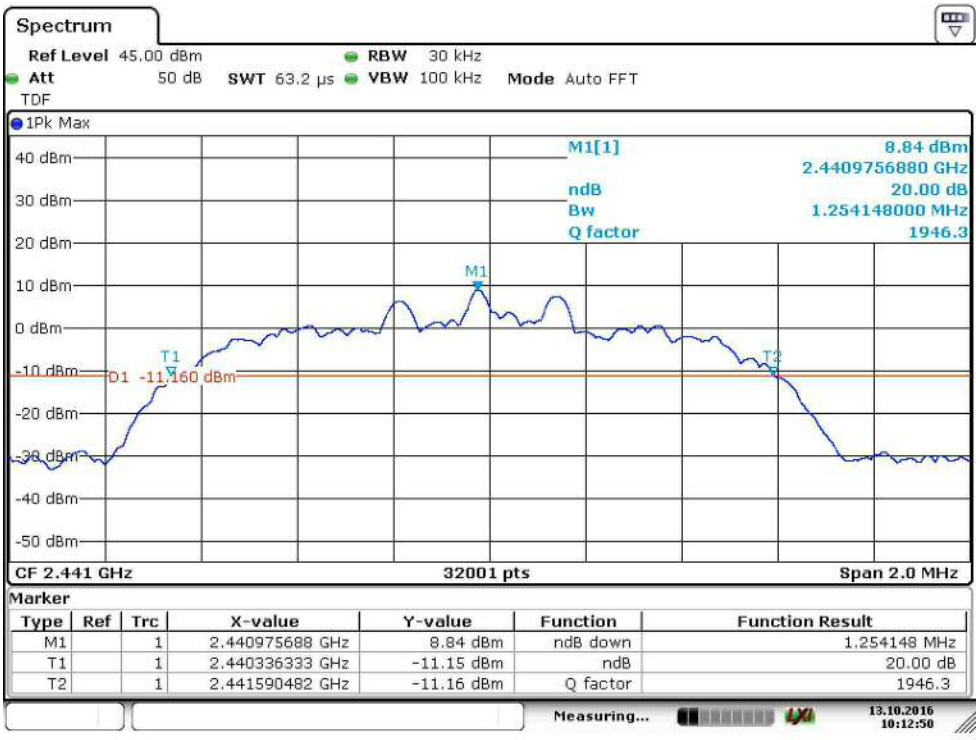


**Figure 21:** 20 dB bandwidth channel mid (3 Mbps)

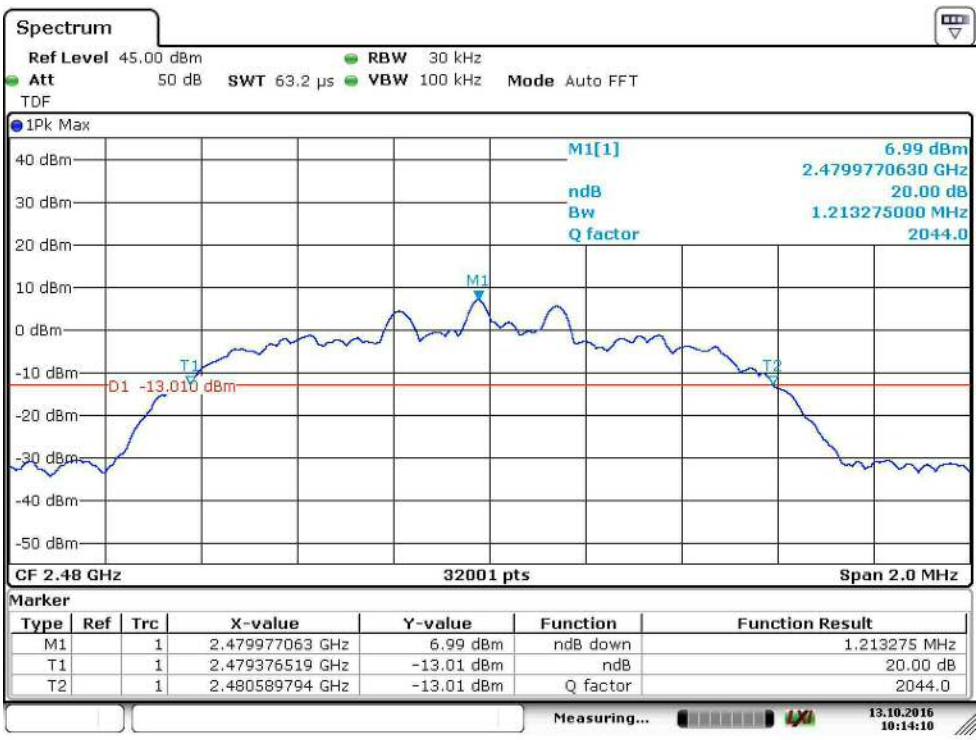


**Figure 22:** 20 dB bandwidth channel high (3Mbps)

## Conducted Spurious Emissions 30 MHz - 26500 MHz and Band Edge

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2014) |
| **Tested by:** | RRE / EHA | |
| **Date:** | 8 August 2016 - 13 October 2016 | |
| **Temperature:** | 21 - 22 °C | |
| **Humidity:** | 33 - 52 % RH | |

**FCC Rule: §15.247(d)**
**RSS-247 5.5**

**Test results:**

**Conducted spurious emissions channel low (GFSK)**

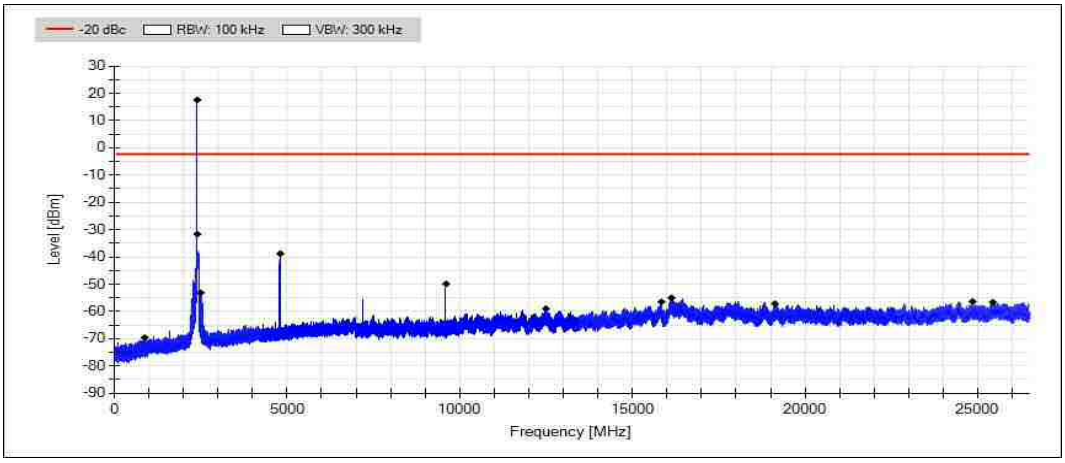


**Figure 23:** Plot of conducted spurious emissions channel low (1 Mbps)

**Table 1:** Final results of conducted spurious emissions channel low (1 Mbps)

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|---|---|---|---|---|
| 880.68 | -69.60 | -2.36 | -67.24 | PASS |
| 2399.98 | -31.60 | -2.36 | -29.24 | PASS |
| 2402.14 | 17.64 | - | - | Carrier |
| 2498.03 | -53.13 | -2.36 | -50.77 | PASS |
| 4804.30 | -38.80 | -2.36 | -36.44 | PASS |
| 9608.00 | -49.91 | -2.36 | -47.55 | PASS |
| 12492.97 | -58.97 | -2.36 | -56.61 | PASS |
| 15836.36 | -56.48 | -2.36 | -54.13 | PASS |
| 16130.54 | -55.01 | -2.36 | -52.65 | PASS |
| 19125.57 | -57.18 | -2.36 | -54.82 | PASS |
| 24847.71 | -56.37 | -2.36 | -54.01 | PASS |
| 25429.71 | -56.59 | -2.36 | -54.23 | PASS |

**Conducted spurious emissions channel mid (GFSK)**

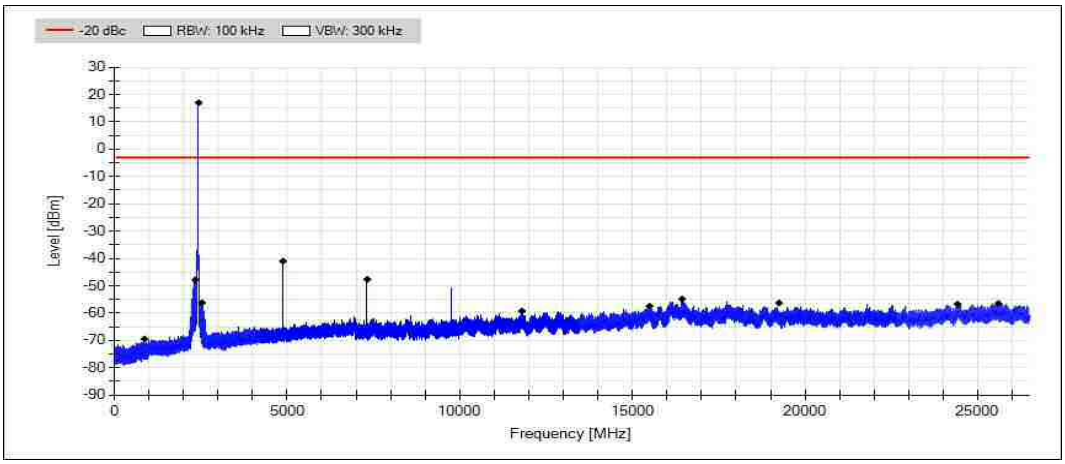


**Figure 24:** Plot of conducted spurious emissions channel mid (1 Mbps)

**Table 2:** Final results of conducted spurious emissions channel mid (1 Mbps)

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|---|---|---|---|---|
| 875.34 | -69.43 | -2.97 | -66.45 | PASS |
| 2345.16 | -47.81 | -2.97 | -44.84 | PASS |
| 2441.14 | 17.03 | - | - | Carrier |
| 2536.98 | -56.18 | -2.97 | -53.21 | PASS |
| 4881.93 | -40.95 | -2.97 | -37.98 | PASS |
| 7323.47 | -47.65 | -2.97 | -44.67 | PASS |
| 11800.93 | -59.26 | -2.97 | -56.29 | PASS |
| 15490.44 | -57.44 | -2.97 | -54.47 | PASS |
| 16437.10 | -54.85 | -2.97 | -51.87 | PASS |
| 19245.01 | -56.30 | -2.97 | -53.32 | PASS |
| 24412.16 | -56.69 | -2.97 | -53.72 | PASS |
| 25593.49 | -56.46 | -2.97 | -53.49 | PASS |

**Conducted spurious emissions channel high (GFSK)**

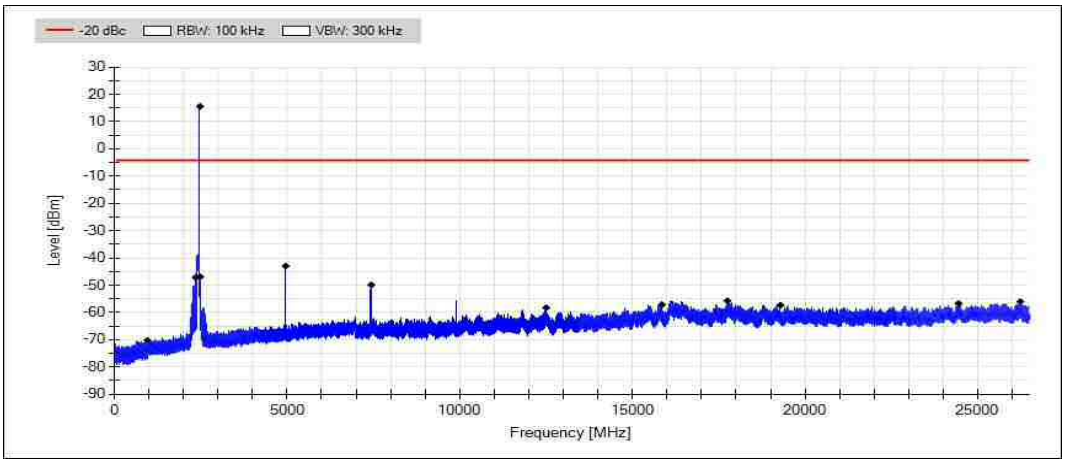


**Figure 25:** Plot of conducted spurious emissions channel high (1 Mbps)

**Table 3:** Final results of conducted spurious emissions channel high (1 Mbps)

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|---|---|---|---|---|
| 953.15 | -70.23 | -4.41 | -65.82 | PASS |
| 2351.99 | -47.12 | -4.41 | -42.71 | PASS |
| 2480.14 | 15.59 | - | - | Carrier |
| 2486.08 | -46.92 | -4.41 | -42.51 | PASS |
| 4960.02 | -42.95 | -4.41 | -38.54 | PASS |
| 7440.47 | -49.87 | -4.41 | -45.45 | PASS |
| 12502.81 | -58.28 | -4.41 | -53.86 | PASS |
| 15853.90 | -57.15 | -4.41 | -52.73 | PASS |
| 17747.12 | -55.72 | -4.41 | -51.31 | PASS |
| 19284.10 | -57.33 | -4.41 | -52.91 | PASS |
| 24443.19 | -56.69 | -4.41 | -52.28 | PASS |
| 26227.83 | -56.02 | -4.41 | -51.60 | PASS |

**Conducted band edge measurements (GFSK)**

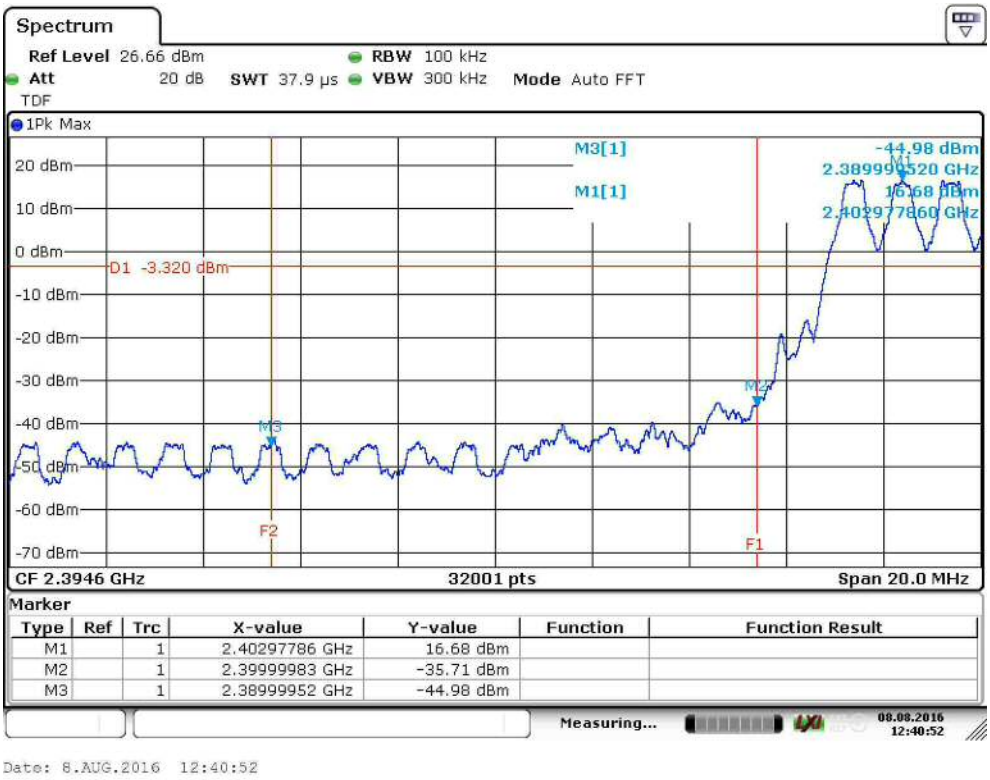


**Figure 26:** Low channel conducted emission at band edge, hopping (1 Mbps)

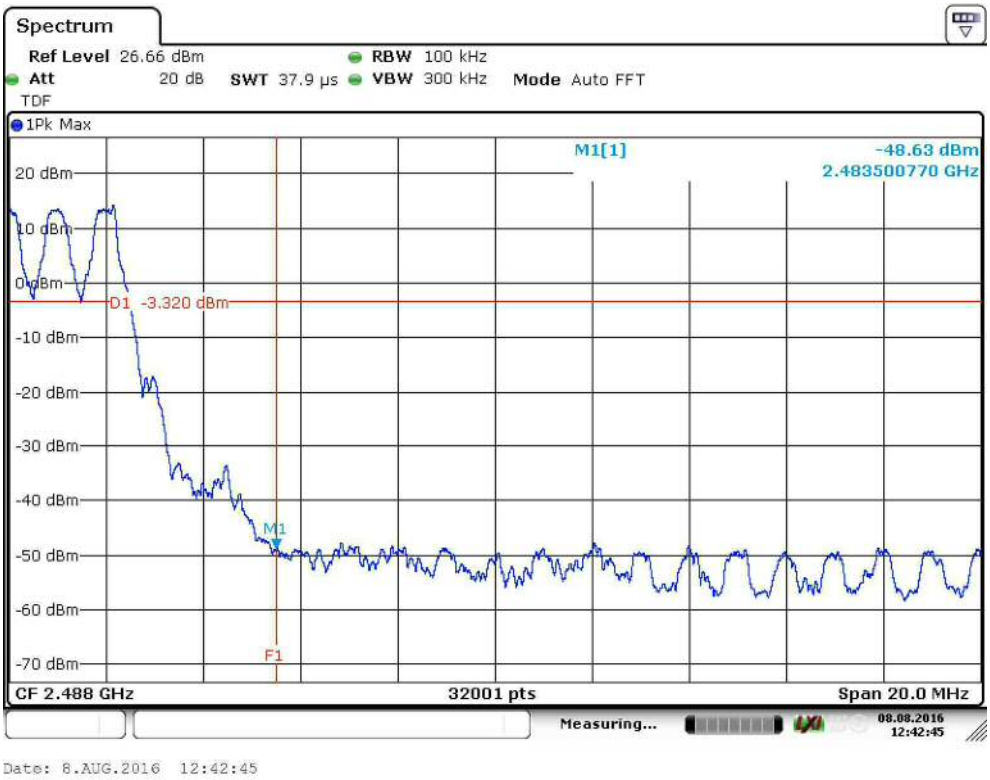


**Figure 27:** High channel conducted emission at band edge, hopping (1 Mbps)

**Conducted spurious emissions channel low (8DPSK)**

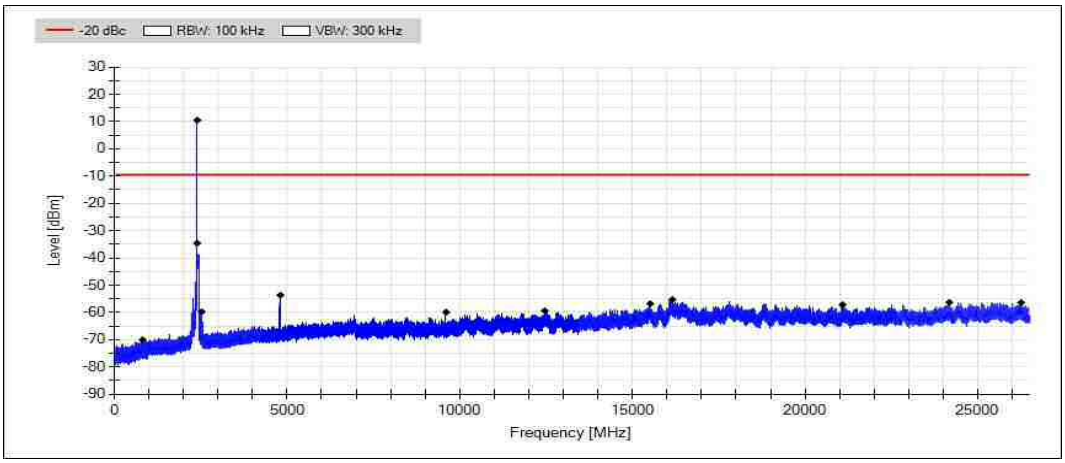


**Figure 28:** Plot of conducted spurious emissions channel low (3 Mbps)

**Table 4:** Final results of conducted spurious emissions channel low (3 Mbps)

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|---|---|---|---|---|
| 816.72 | -70.04 | -9.48 | -60.56 | PASS |
| 2399.63 | -34.59 | -9.48 | -25.12 | PASS |
| 2401.81 | 10.52 | - | - | Carrier |
| 2530.06 | -59.74 | -9.48 | -50.26 | PASS |
| 4804.30 | -53.65 | -9.48 | -44.18 | PASS |
| 9608.00 | -59.93 | -9.48 | -50.46 | PASS |
| 12463.44 | -59.38 | -9.48 | -49.90 | PASS |
| 15515.56 | -56.84 | -9.48 | -47.36 | PASS |
| 16153.61 | -55.27 | -9.48 | -45.79 | PASS |
| 21080.86 | -57.15 | -9.48 | -47.68 | PASS |
| 24174.42 | -56.29 | -9.48 | -46.81 | PASS |
| 26250.94 | -56.37 | -9.48 | -46.90 | PASS |

**Conducted spurious emissions channel mid (8DPSK)**

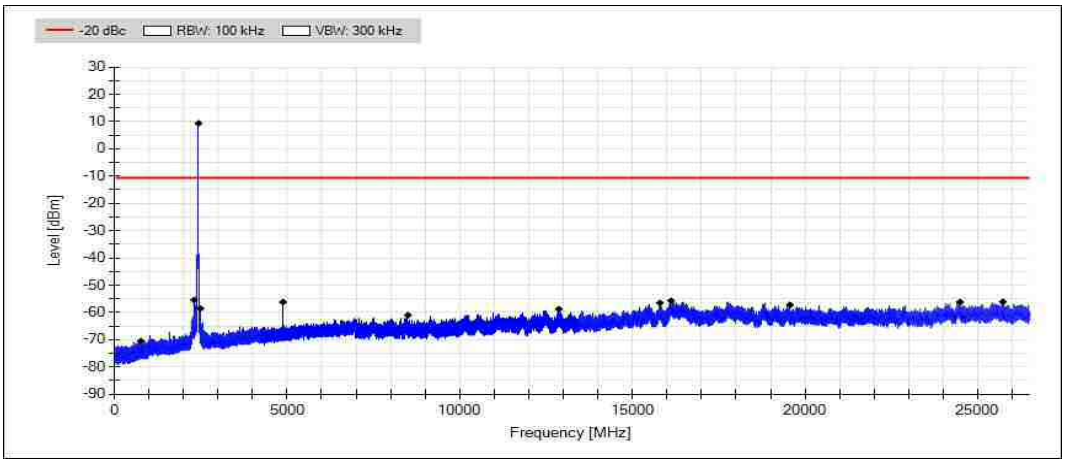


**Figure 29:** Plot of conducted spurious emissions channel mid (3 Mbps)

**Table 5:** Final results of conducted spurious emissions channel mid (3 Mbps)

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|---|---|---|---|---|
| 766.65 | -70.51 | -10.61 | -59.90 | PASS |
| 2312.96 | -55.43 | -10.61 | -44.83 | PASS |
| 2440.81 | 9.39 | - | - | Carrier |
| 2489.12 | -58.53 | -10.61 | -47.92 | PASS |
| 4882.30 | -56.18 | -10.61 | -45.58 | PASS |
| 8502.06 | -61.00 | -10.61 | -50.39 | PASS |
| 12870.11 | -58.79 | -10.61 | -48.19 | PASS |
| 15793.24 | -56.49 | -10.61 | -45.89 | PASS |
| 16120.14 | -55.74 | -10.61 | -45.13 | PASS |
| 19558.50 | -57.24 | -10.61 | -46.63 | PASS |
| 24481.91 | -56.17 | -10.61 | -45.56 | PASS |
| 25721.83 | -56.11 | -10.61 | -45.50 | PASS |

**Conducted spurious emissions channel high (8DPSK)**

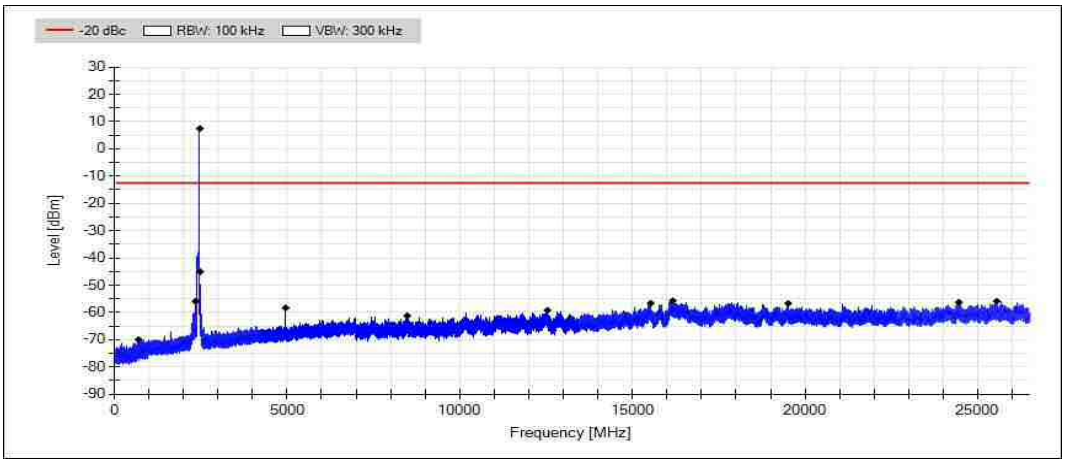


**Figure 30:** Plot of conducted spurious emissions channel high (3 Mbps)

**Table 6:** Final results of conducted spurious emissions channel high (3 Mbps)

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|---|---|---|---|---|
| 706.05 | -69.96 | -12.53 | -57.43 | PASS |
| 2351.99 | -55.87 | -12.53 | -43.34 | PASS |
| 2479.81 | 7.47 | - | - | Carrier |
| 2483.52 | -45.06 | -12.53 | -32.53 | PASS |
| 4960.30 | -58.33 | -12.53 | -45.80 | PASS |
| 8476.00 | -61.23 | -12.53 | -48.70 | PASS |
| 12538.16 | -59.23 | -12.53 | -46.70 | PASS |
| 15529.81 | -56.63 | -12.53 | -44.10 | PASS |
| 16167.29 | -55.71 | -12.53 | -43.18 | PASS |
| 19509.38 | -56.67 | -12.53 | -44.14 | PASS |
| 24452.66 | -56.27 | -12.53 | -43.74 | PASS |
| 25547.32 | -55.88 | -12.53 | -43.35 | PASS |

**Conducted band edge measurements (8DPSK)**

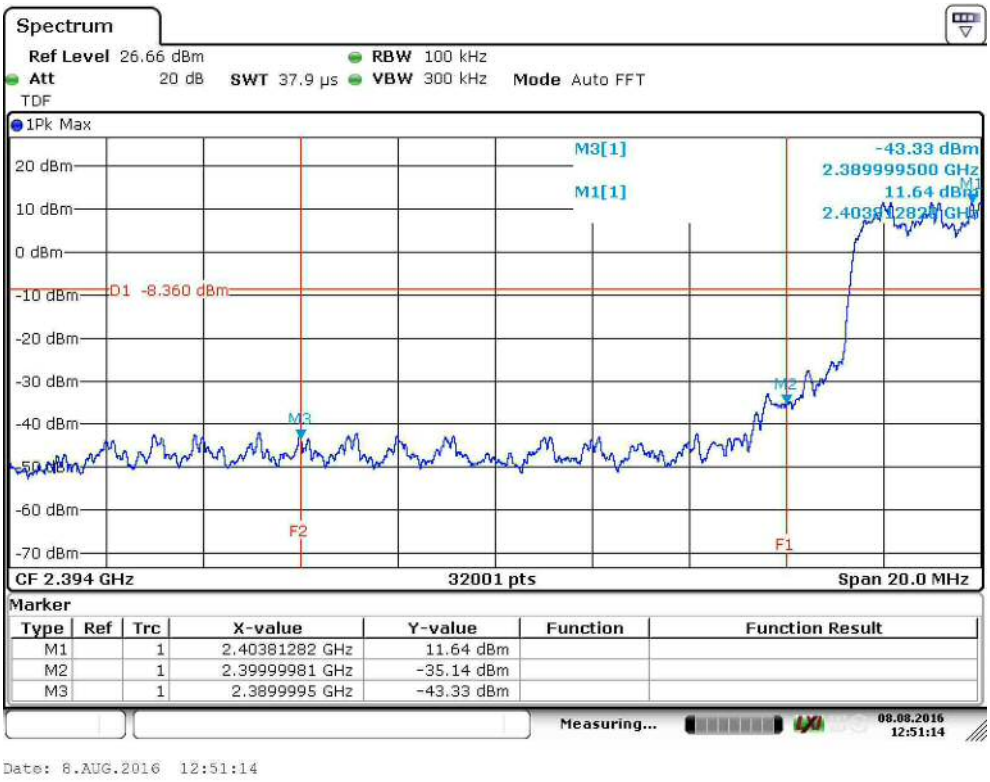


**Figure 31:** Low channel conducted emission at band edge, hopping (3 Mbps)

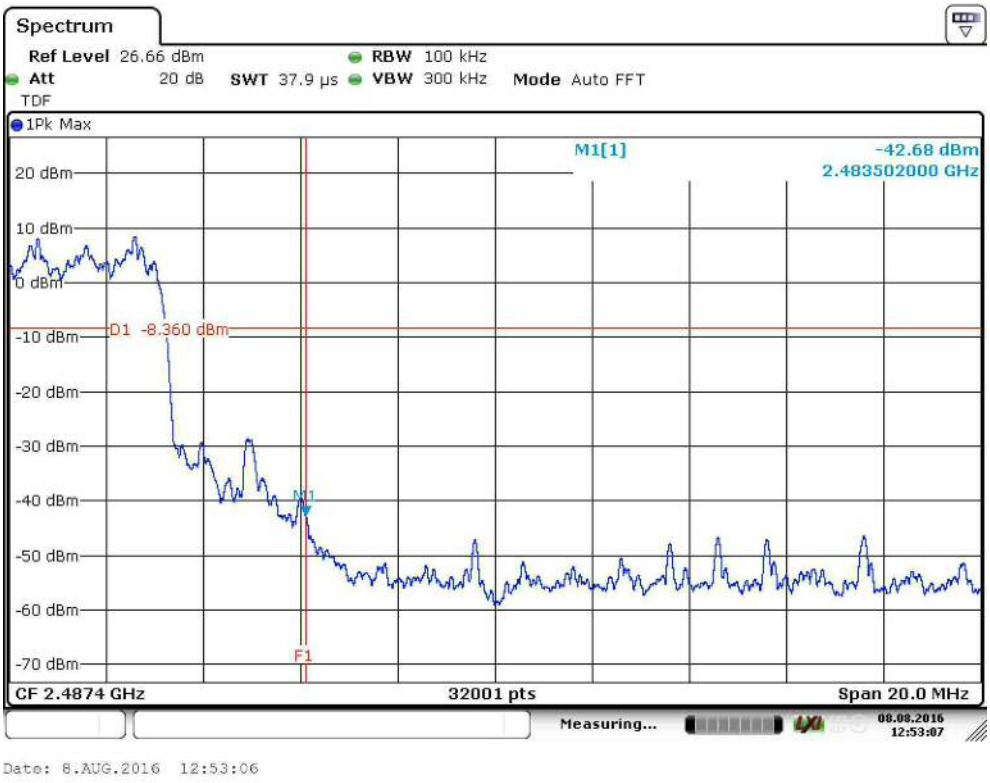


**Figure 32:** High channel conducted emission at band edge, hopping (3 Mbps)

## Transmitter Radiated Emissions 30 MHz - 26500 MHz and Band Edge

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | RRE / EHA | |
| **Date:** | 2 August 2016 - 12 October 2016 | |
| **Temperature:** | 20 - 22 °C | |
| **Humidity:** | 38 - 54 % RH | |
| **Measurement uncertainty:** | ± 4.51 dB | Level of confidence 95 % (k = 2) |

**FCC Rule: §15.247(d), 15.209(a)**
**RSS-247: 5.5**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a).

The correction factor in the final result table contains the sum of the transducers (antenna + amplifier + cables). The result value is the measured value corrected with the correction factor. Measurements were done with 1 Mbps (worst case). Duty cycle correction factor (30.7 dB) is embedded to the calculated average result.

**Low channel, WT41u-A**

**Table 7:** Quasi-peak results (ch low)

| Frequency (MHz) | QuasiPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 51.465000 | 11.4 | 260.0 | H | 106.0 | 14.6 | 28.6 | 40.0 |
| 945.717000 | 26.6 | 128.0 | H | 1.0 | 27.7 | 19.4 | 46.0 |

**Table 8:** Peak results (ch low)

| Frequency (MHz) | MaxPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 1601.675000 | 47.2 | 166.0 | H | 143.0 | 2.8 | 26.7 | 73.9 |
| 2375.825000 | 50.9 | 216.0 | H | 143.0 | 8.8 | 23.0 | 73.9 |
| 2385.800000 | 36.5 | 265.0 | H | 296.0 | 4.0 | 37.4 | 73.9 |
| 2400.000000 | 48.0 | 397.0 | H | 299.0 | 4.1 | 25.9 | 73.9 |
| 2401.800000 | 104.5 | 191.0 | H | 327.0 | 9.0 | - | - |
| 4803.800000 | 41.1 | 299.0 | V | 332.0 | 10.4 | 32.8 | 73.9 |
| 7205.400000 | 47.6 | 312.0 | V | 344.0 | 12.6 | 26.3 | 73.9 |
| 9608.600000 | 40.5 | 297.0 | V | 32.0 | 15.2 | 33.4 | 73.9 |

**Table 9:** Average results (ch low)

| Frequency (MHz) | Average (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 2375.825000 | 20.2 | 216.0 | H | 143.0 | 8.8 | 33.7 | 53.9 |
| 2385.800000 | 5.8 | 265.0 | H | 296.0 | 4.0 | 48.1 | 53.9 |
| 2400.000000 | 17.3 | 397.0 | H | 299.0 | 4.1 | 36.6 | 53.9 |
| 4803.800000 | 10.4 | 299.0 | V | 332.0 | 10.4 | 43.5 | 53.9 |
| 7205.400000 | 16.9 | 312.0 | V | 344.0 | 12.6 | 37.0 | 53.9 |

**Middle channel, WT41u-A**

**Table 10:** Quasi-peak results (ch mid)

| Frequency (MHz) | QuasiPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 55.397000 | 11.3 | 327.0 | H | 155.0 | 14.4 | 28.7 | 40.0 |
| 108.818000 | 8.7 | 208.0 | H | 141.0 | 11.3 | 34.8 | 43.5 |
| 945.497000 | 26.6 | 215.0 | V | 1.0 | 27.7 | 19.4 | 46.0 |

**Table 11:** Peak results (ch mid)

| Frequency (MHz) | MaxPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 1627.725000 | 48.6 | 190.0 | H | 143.0 | 3.6 | 25.3 | 73.9 |
| 2440.800000 | 104.9 | 179.0 | H | 322.0 | 8.9 | - | - |
| 4882.000000 | 39.7 | 246.0 | V | 344.0 | 10.4 | 34.2 | 73.9 |
| 9764.700000 | 35.8 | 298.0 | V | 132.0 | 15.3 | 38.1 | 73.9 |

**Table 12:** Average results (ch mid)

| Frequency (MHz) | Average (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 1627.725000 | 17.9 | 190.0 | H | 143.0 | 3.6 | 36.0 | 53.9 |
| 4882.000000 | 9.0 | 246.0 | V | 344.0 | 10.4 | 44.9 | 53.9 |
| 9764.700000 | 5.1 | 298.0 | V | 132.0 | 15.3 | 48.8 | 53.9 |

**High channel, WT41u-A**

**Table 13:** Quasi-peak results (ch high)

| Frequency (MHz) | QuasiPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 50.227000 | 11.5 | 100.0 | H | 302.0 | 14.6 | 28.5 | 40.0 |
| 955.611000 | 26.7 | 364.0 | H | 215.0 | 27.8 | 19.3 | 46.0 |

**Table 14:** Peak results (ch high)

| Frequency (MHz) | MaxPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 1653.725000 | 51.7 | 204.0 | H | 117.0 | 4.4 | 22.2 | 73.9 |
| 2479.800000 | 107.4 | 220.0 | H | 318.0 | 9.2 | - | - |
| 2483.500000 | 53.9 | 396.0 | H | 298.0 | 4.4 | 20.0 | 73.9 |
| 2506.625000 | 52.6 | 220.0 | H | 318.0 | 9.3 | 21.3 | 73.9 |
| 4959.700000 | 43.9 | 232.0 | V | 354.0 | 10.4 | 30.0 | 73.9 |
| 9920.600000 | 37.6 | 299.0 | V | 136.0 | 16.0 | 36.3 | 73.9 |

**Table 15:** Average results (ch high)

| Frequency (MHz) | Average (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 1653.725000 | 21.0 | 204.0 | H | 117.0 | 4.4 | 32.9 | 53.9 |
| 2483.500000 | 23.2 | 396.0 | H | 298.0 | 4.4 | 30.7 | 53.9 |
| 2506.625000 | 21.9 | 220.0 | H | 318.0 | 9.3 | 32.0 | 53.9 |
| 4959.700000 | 13.2 | 232.0 | V | 354.0 | 10.4 | 40.7 | 53.9 |
| 9920.600000 | 6.9 | 299.0 | V | 136.0 | 16.0 | 47.0 | 53.9 |

**Radiated band edge measurement results, WT41u-A**

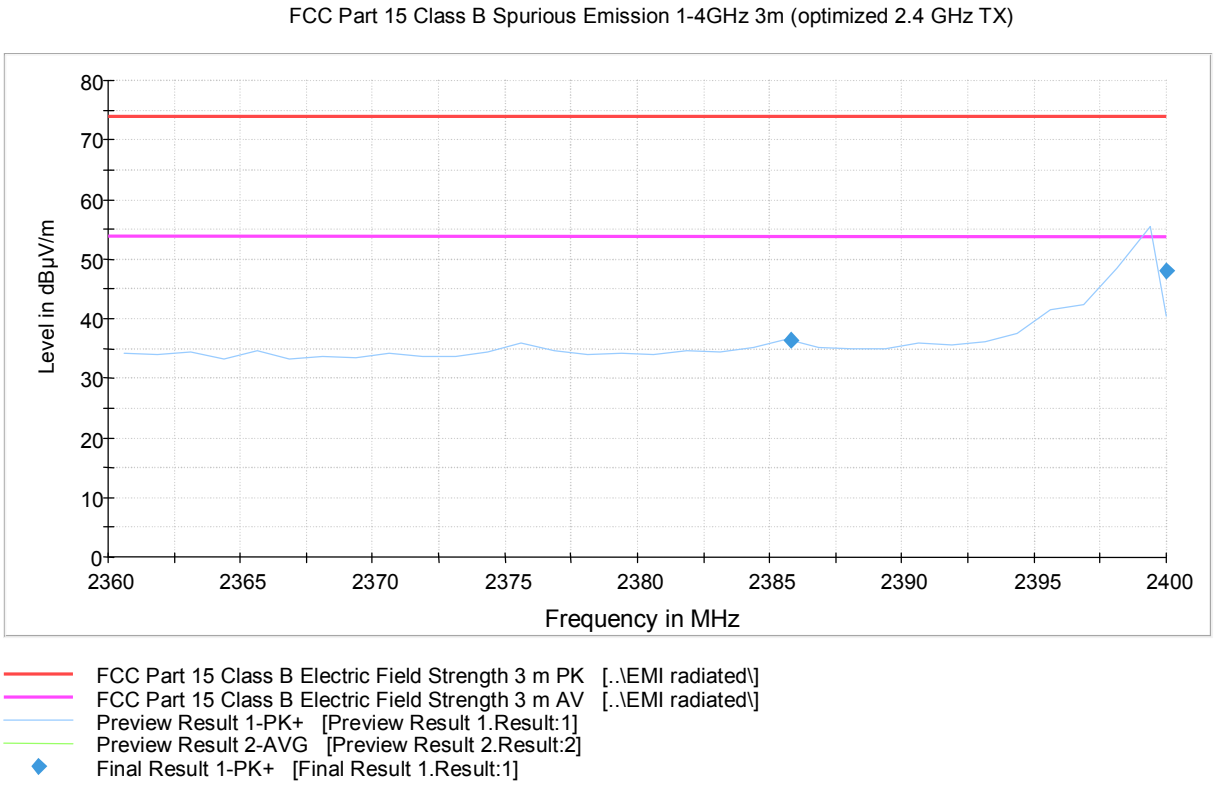


**Figure 33.** Radiated channel low band edge measured with peak detector (WT41u-A)

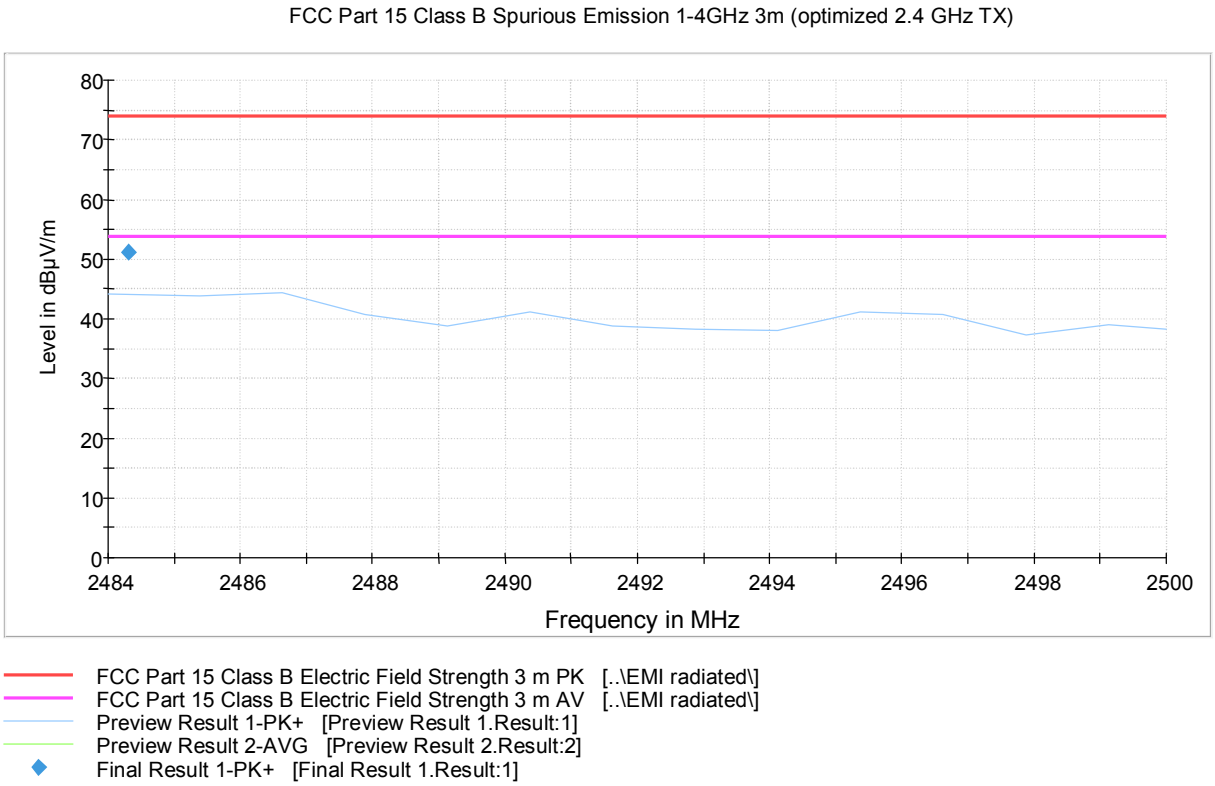


**Figure 34.** Radiated higher band edge measured with peak detector (WT41u-A)

**Low channel, WT41u-E**

**Table 16:** Quasi-peak results (ch low)

| Frequency (MHz) | QuasiPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 255.990000 | 22.9 | 120.0 | H | 303.0 | 13.7 | 23.1 | 46.0 |
| 304.005000 | 25.2 | 100.0 | H | 158.0 | 15.5 | 20.8 | 46.0 |

**Table 17:** Peak results (ch low)

| Frequency (MHz) | MaxPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 1601.675000 | 45.7 | 255.0 | H | 41.0 | 2.8 | 28.2 | 73.9 |
| 2306.025000 | 51.6 | 229.0 | V | 53.0 | 8.4 | 22.3 | 73.9 |
| 2401.800000 | 112.4 | 179.0 | V | 63.0 | 9.0 | - | - |
| 2365.400000 | 43.0 | 150.0 | V | 152.0 | 3.7 | 30.9 | 73.9 |
| 2385.800000 | 50.2 | 150.0 | V | 227.0 | 4.0 | 23.7 | 73.9 |
| 2400.000000 | 69.7 | 249.0 | V | 340.0 | 4.1 | 4.2 | 73.9 |
| 4804.300000 | 48.1 | 150.0 | V | 273.0 | 10.4 | 25.8 | 73.9 |
| 9608.400000 | 47.7 | 297.0 | V | 351.0 | 15.2 | 26.2 | 73.9 |

**Table 18:** Average results (ch low)

| Frequency (MHz) | Average (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 2306.025000 | 20.9 | 229.0 | V | 53.0 | 8.4 | 33.0 | 53.9 |
| 2365.400000 | 12.3 | 150.0 | V | 152.0 | 3.7 | 41.6 | 53.9 |
| 2385.800000 | 19.5 | 150.0 | V | 227.0 | 4.0 | 34.4 | 53.9 |
| 2400.000000 | 39.0 | 249.0 | V | 340.0 | 4.1 | 14.9 | 53.9 |
| 4804.300000 | 17.4 | 150.0 | V | 273.0 | 10.4 | 36.5 | 53.9 |
| 9608.400000 | 17.0 | 297.0 | V | 351.0 | 15.2 | 36.9 | 53.9 |

**Middle channel, WT41u-E**

**Table 19:** Quasi-peak results (ch mid)

| Frequency (MHz) | QuasiPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 256.030000 | 22.8 | 111.0 | H | 298.0 | 13.7 | 23.2 | 46.0 |
| 304.025000 | 27.1 | 100.0 | H | 140.0 | 15.5 | 18.9 | 46.0 |

**Table 20:** Peak results (ch mid)

| Frequency (MHz) | MaxPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 1627.725000 | 46.4 | 400.0 | H | 41.0 | 3.6 | 27.5 | 73.9 |
| 2312.725000 | 52.0 | 204.0 | V | 41.0 | 8.4 | 21.9 | 73.9 |
| 2345.025000 | 52.6 | 253.0 | V | 99.0 | 8.5 | 21.3 | 73.9 |
| 2440.800000 | 112.0 | 191.0 | V | 296.0 | 8.9 | - | - |
| 4881.700000 | 47.2 | 160.0 | V | 232.0 | 10.4 | 26.7 | 73.9 |
| 9763.900000 | 39.7 | 299.0 | V | 164.0 | 15.3 | 34.2 | 73.9 |

**Table 21:** Average results (ch mid)

| Frequency (MHz) | Average (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 2312.725000 | 21.3 | 204.0 | V | 41.0 | 8.4 | 32.6 | 53.9 |
| 2345.025000 | 21.9 | 253.0 | V | 99.0 | 8.5 | 32.0 | 53.9 |
| 4881.700000 | 16.5 | 160.0 | V | 232.0 | 10.4 | 37.4 | 53.9 |
| 9763.900000 | 9.0 | 299.0 | V | 164.0 | 15.3 | 44.9 | 53.9 |

**High channel, WT41u-E**

**Table 22:** Quasi-peak results (ch high)

| Frequency (MHz) | QuasiPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 207.975000 | 23.4 | 173.0 | H | 291.0 | 11.5 | 20.1 | 43.5 |
| 303.945000 | 26.0 | 111.0 | H | 316.0 | 15.5 | 20.0 | 46.0 |

**Table 23:** Peak results (ch high)

| Frequency (MHz) | MaxPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 1653.575000 | 48.6 | 166.0 | H | 146.0 | 4.4 | 25.3 | 73.9 |
| 2292.325000 | 48.4 | 191.0 | V | 55.0 | 8.3 | 25.5 | 73.9 |
| 2320.175000 | 50.2 | 191.0 | V | 42.0 | 8.4 | 23.7 | 73.9 |
| 2352.075000 | 52.3 | 228.0 | V | 143.0 | 8.6 | 21.6 | 73.9 |
| 2384.175000 | 52.4 | 241.0 | V | 101.0 | 8.9 | 21.5 | 73.9 |
| 2479.800000 | 110.8 | 150.0 | V | 47.0 | 9.2 | - | - |
| 2495.825000 | 54.2 | 248.0 | V | 143.0 | 9.3 | 19.7 | 73.9 |
| 2506.225000 | 53.9 | 150.0 | V | 46.0 | 9.3 | 20.0 | 73.9 |
| 4959.700000 | 47.2 | 248.0 | V | 22.0 | 10.4 | 26.7 | 73.9 |

**Table 24:** Average results (ch high)

| Frequency (MHz) | Average (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|
| 2320.175000 | 19.5 | 191.0 | V | 42.0 | 8.4 | 34.4 | 53.9 |
| 2352.075000 | 21.6 | 228.0 | V | 143.0 | 8.6 | 32.3 | 53.9 |
| 2384.175000 | 21.7 | 241.0 | V | 101.0 | 8.9 | 32.2 | 53.9 |
| 2495.825000 | 23.5 | 248.0 | V | 143.0 | 9.3 | 30.4 | 53.9 |
| 2506.225000 | 23.2 | 150.0 | V | 46.0 | 9.3 | 30.7 | 53.9 |
| 4959.700000 | 16.5 | 248.0 | V | 22.0 | 10.4 | 37.4 | 53.9 |

**Radiated band edge measurement results, WT41u-E**

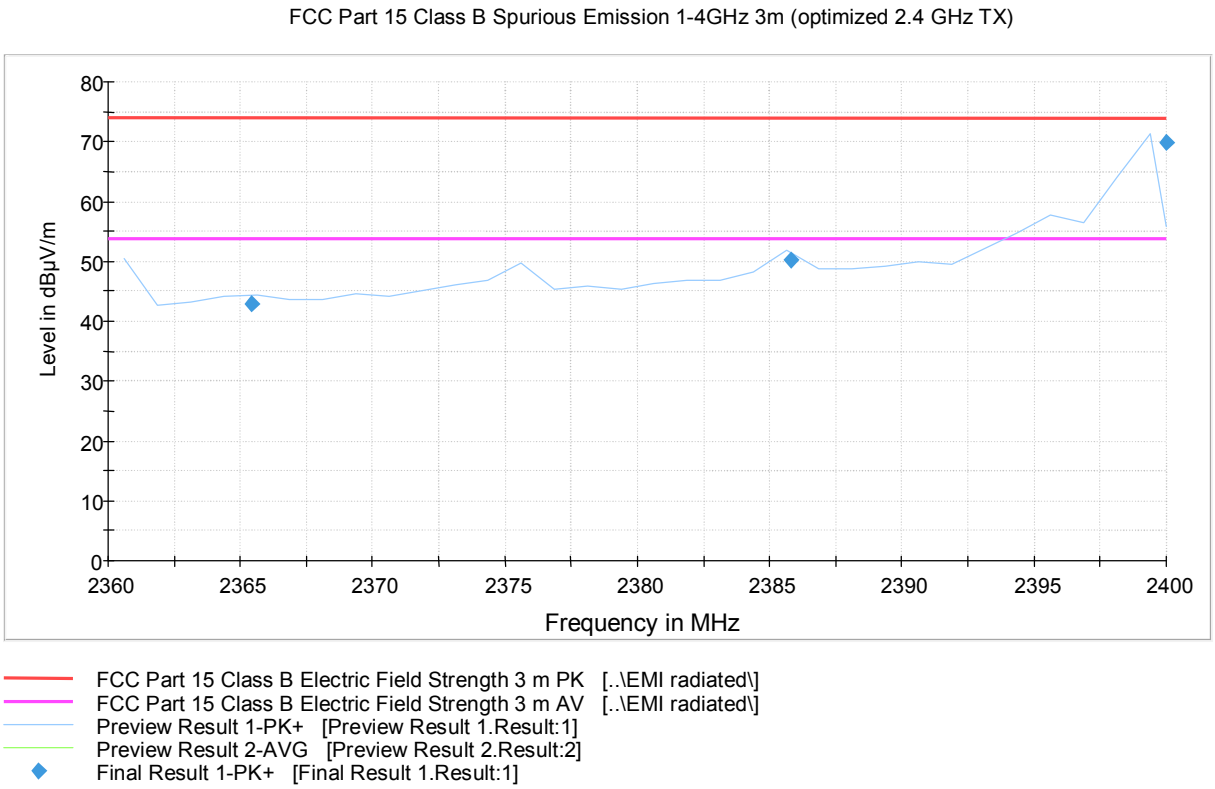


**Figure 35.** Radiated channel low band edge measured with peak detector (WT41u-E)

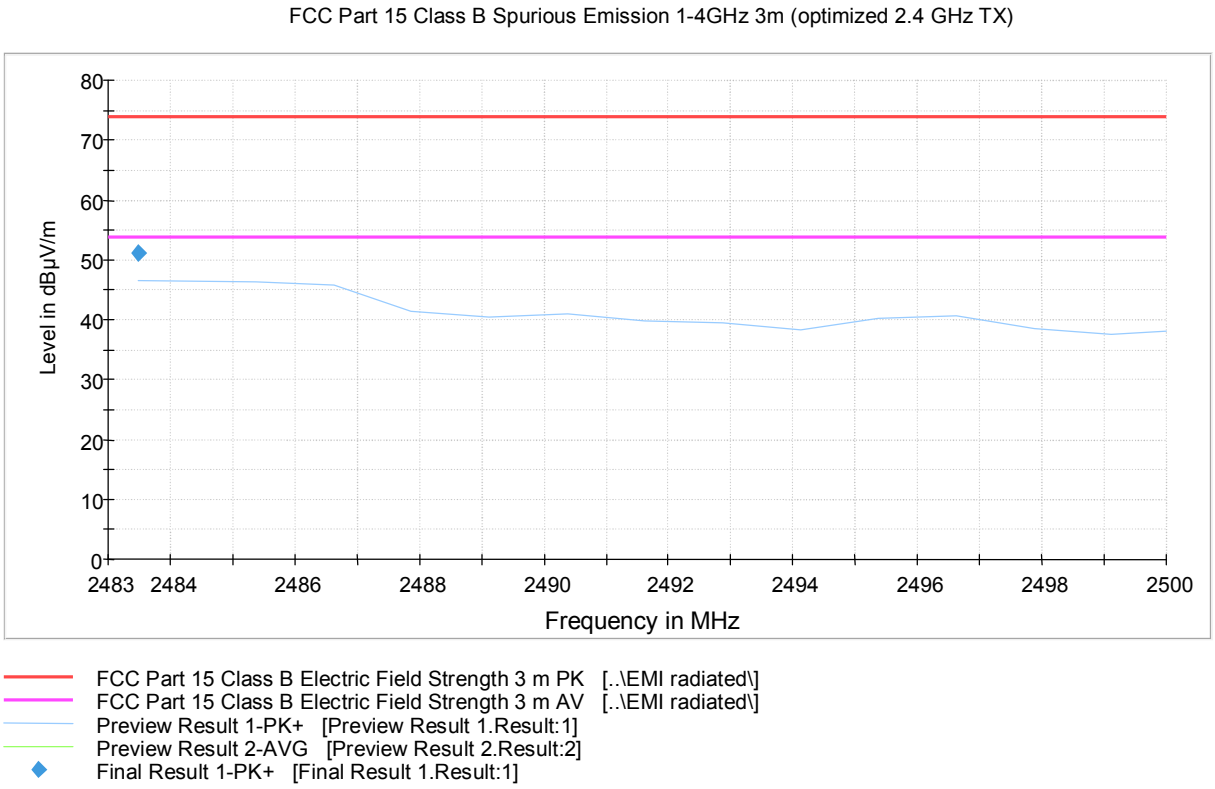


**Figure 36.** Radiated channel higher band edge measured with peak detector (WT41u-E)

## 99% Occupied Bandwidth

| | | |
|---|---|---|
| **Standard:** | RSS-GEN | (2014) |
| **Tested by:** | RRE | |
| **Date:** | 8 August 2016 | |
| **Temperature:** | 22 °C | |
| **Humidity:** | 52 % RH | |

**RSS-GEN 6.6**

**Table 9.** 99% bandwidth test results 1 Mbps

| Channel | 99% BW [MHz] | Limit | Result |
|---|---|---|---|
| Low | 0.998718790038 | - | **PASS** |
| Mid | 0.994031436518 | - | **PASS** |
| High | 0.984344239243 | - | **PASS** |

**Table 10.** 99% bandwidth test results 2 Mbps

| Channel | 99% BW [MHz] | Limit | Result |
|---|---|---|---|
| Low | 1.213399581 | - | **PASS** |
| Mid | 1.207462267 | - | **PASS** |
| High | 1.212774601 | - | **PASS** |

**Table 11.** 99% bandwidth test results 3 Mbps

| Channel | 99% BW [MHz] | Limit | Result |
|---|---|---|---|
| Low | 1.217149464 | - | **PASS** |
| Mid | 1.216211993 | - | **PASS** |
| High | 1.214649542 | - | **PASS** |

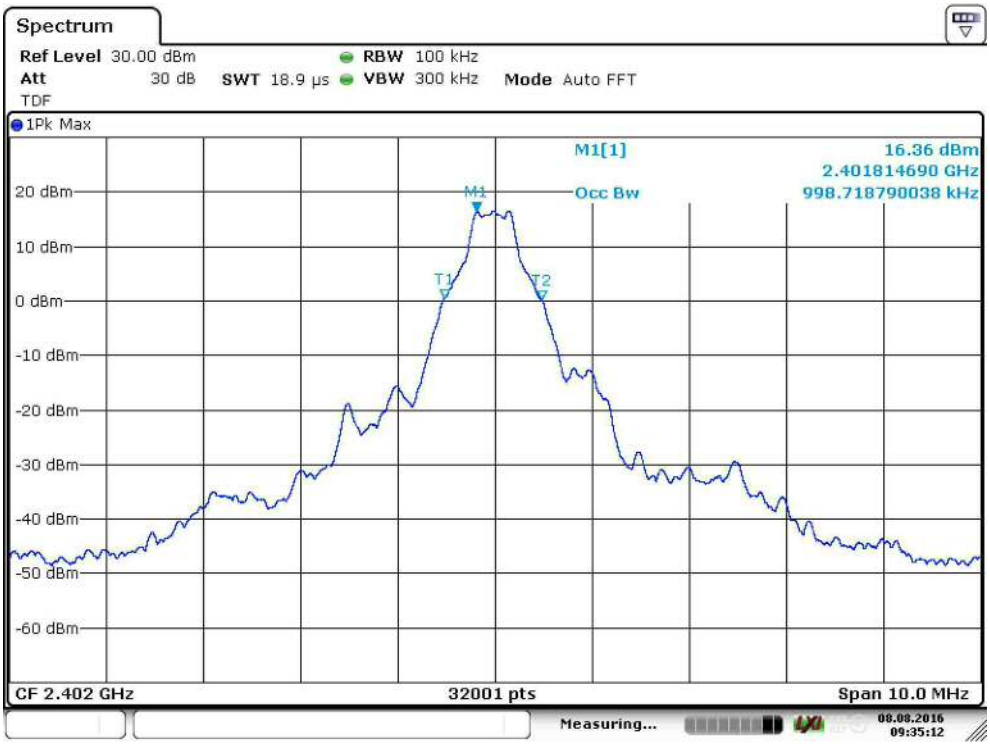


**Figure 37.** 99 % OBW channel low (1 Mbps)

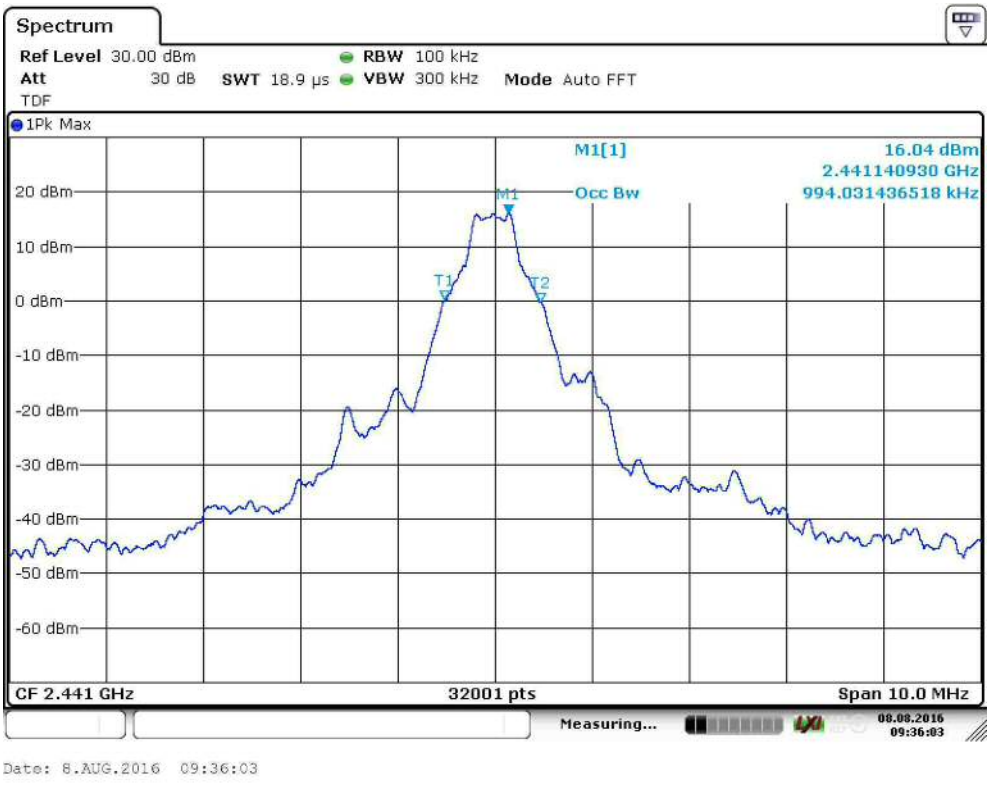


**Figure 38.** 99 % OBW channel mid (1 Mbps)

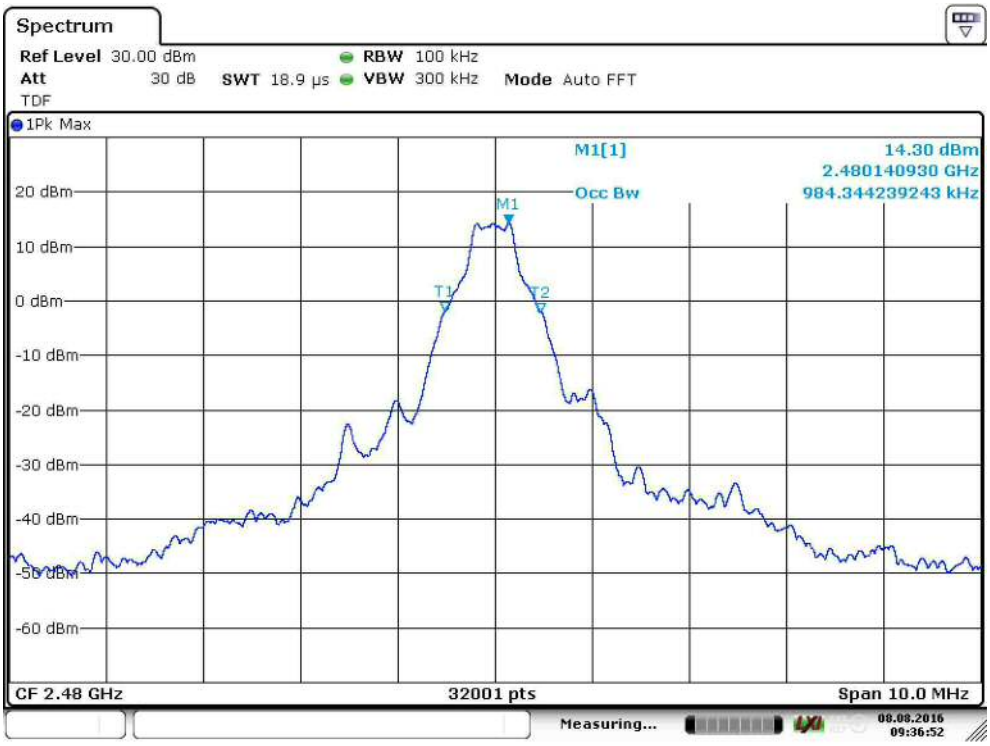


**Figure 39.** 99 % OBW channel high (1 Mbps)

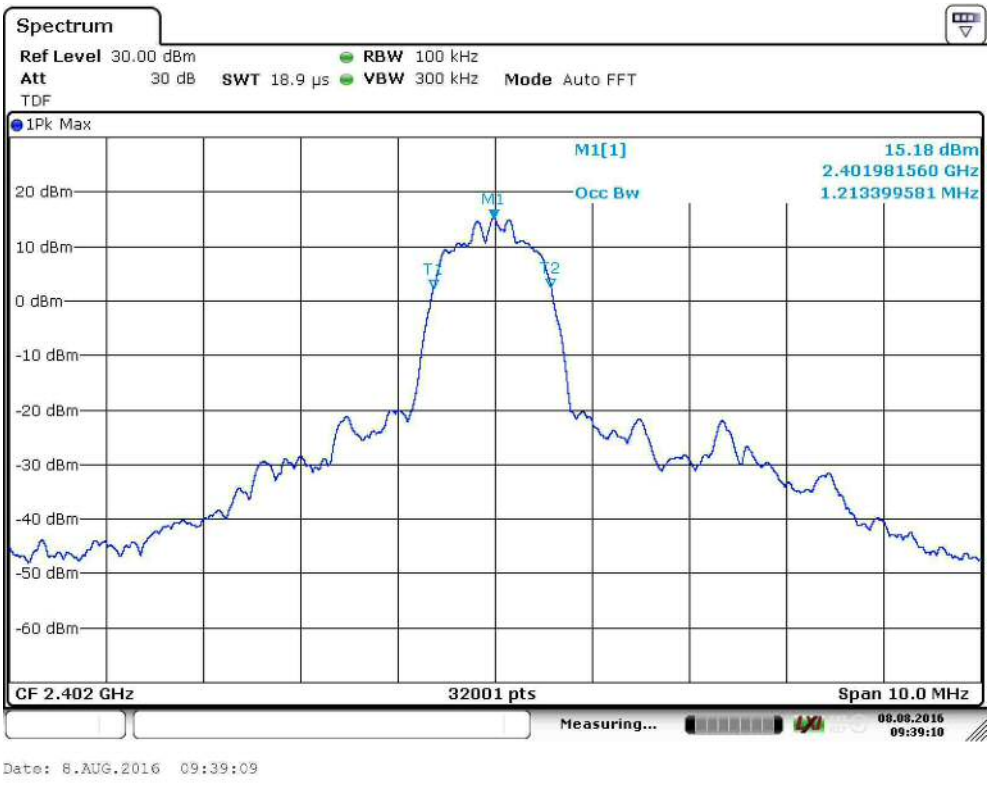


**Figure 40.** 99 % OBW channel low (2 Mbps)

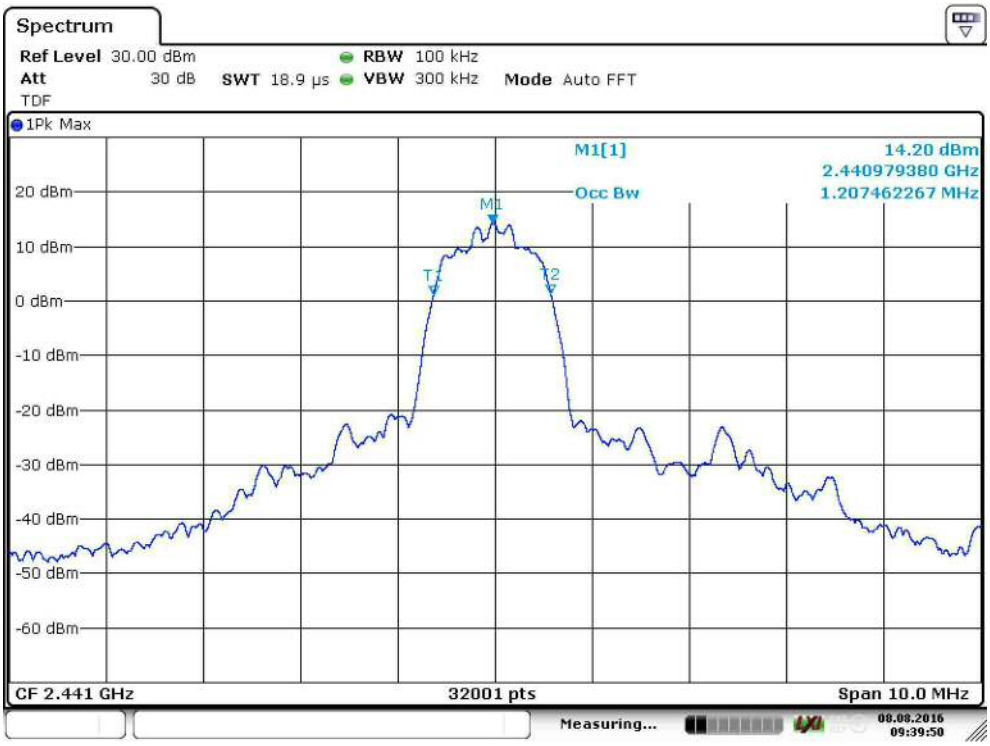


**Figure 41.** 99 % OBW channel mid (2 Mbps)


**Figure 42.** 99 % OBW channel high (2 Mbps)

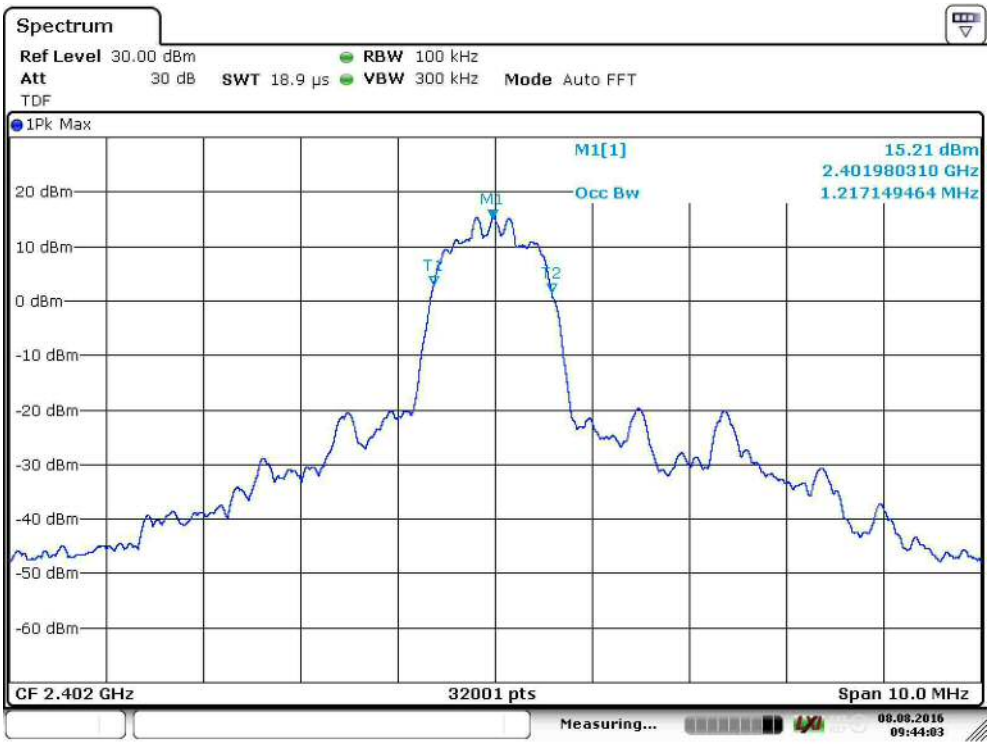


**Figure 43.** 99 % OBW channel low (3 Mbps)


**Figure 44.** 99 % OBW channel mid (3 Mbps)

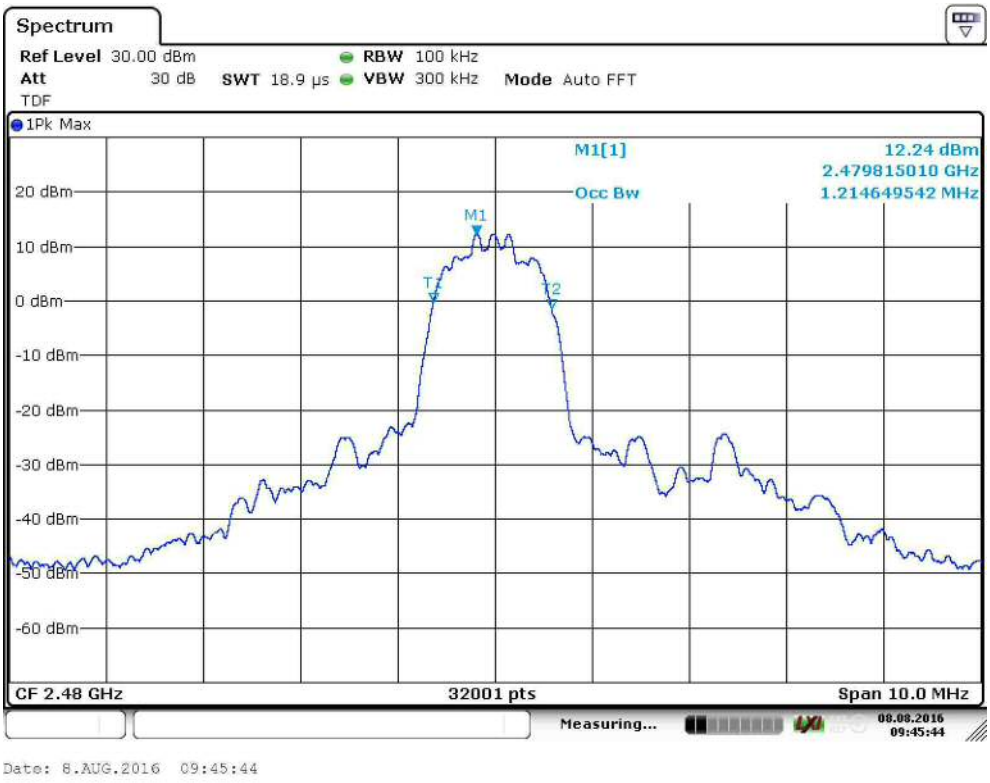


**Figure 45.** 99 % OBW channel high (3 Mbps)

# TEST EQUIPMENT

## RF Test Equipment

| Equipment | Manufacturer | Type | Inv number | Prev Calib | Next Calib |
|---|---|---|---|---|---|
| ATTENUATOR 10 dB | PASTERNACK | PE7090-10 | - | 2016-04-01 | 2017-04-01 |
| RF SIGNAL GENERATOR | ANRITSU | MG3694B | 9753 | 2015-10-13 | 2017-10-13 |
| TURNTABLE | DEISEL | DS 430+upgrade | - | - | - |
| MAST & TURNTABLE CONTROLLER | MATURO | NCD | 10183 | - | - |
| ANTENNA MAST | MATURO | TAM 4.0E | 10181 | - | - |
| ANTENNA | SCHWARZBECK | VULB 9168 | inv:8911 | 2014-11-04 | 2016-11-04 |
| ANTENNA | EMCO | 3117 | inv:7293 | 2016-03-16 | 2018-03-06 |
| ANTENNA | EMCO | 3160-09 | inv:7294 | 2016-03-16 | 2017-03-16 |
| PREAMPLIFIER | ALC MICROWAWE | AWB-2018-40-08 | sn:14 | 2016-08-30 | 2017-08-30 |
| PREAMPLIFIER | MERCURY SYSTEMS | ALS1826-41-12 | - | 2016-09-02 | 2017-09-02 |
| TEST SOFTWARE | ROHDE & SCHWARZ | EMC-32 | - | - | - |
| EMI TEST RECEIVER | ROHDE & SCHWARZ | ESU 26 | 8453 | 2016-06-10 | 2017-06-10 |
| SIGNAL ANALYZER | ROHDE & SCHWARZ | FSV40 | 9093 | 2016-06-10 | 2017-06-10 |
| SWITCH UNIT | ROHDE & SCHWARZ | OSP 120 | 9289 | 2016-03-14 | 2019-03-14 |
| RF SIGNAL GENERATOR | ROHDE & SCHWARZ | SMB100A | 9288 | 2014-03-18 | 2017-03-18 |
| VECTOR SIGNAL GENERATOR | ROHDE & SCHWARZ | SMBV100A | 9290 | 2014-03-13 | 2017-03-17 |
| ANTENNA | SCHWARZBECK | VULB 9168 | 8911 | 2014-11-04 | 2016-11-04 |
| TEMPERATURE/ HUMIDITY METER | VAISALA | HMT 333 | 8638 | 2016-03-01 | 2017-03-01 |
| HIGH PASS FILTER | WAINWRIGHT | WHKX4.0/18G-10SS | - | 2016-01-22 | 2017-01-22 |
| MULTIMETER | FLUKE | 23 | 8252 | 2015-10-20 | 2016-10-20 |
| PRECISION DC POWER SUPPLY | THANDAR | TS3021S | 099609 | - | - |
| AC POWER SOURCE | CALIFORNIA INSTRUMENTS | 5001 iX Series II | 7826 | - | - |